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SYNOPSIS

The morphology of fossil dinoflagellate cysts and acritarchs from the base of the Kimmeridgian (Baylei Zone) of England, Scotland and France is described. The cysts are shown to fall into three broad groups—" proximate ", " chorate " and " cavate "—which are interpreted as indicating different modes of formation.

Two new genera and twelve new species, together with three new subspecies are proposed and described. The diagnosis of the genera *Cryptarchaeodinium* (Deflandre) and *Staplinium* (Jansonius), the species *Gonyaulacysta hyaloderma* (Deflandre) and *Leptodinium arcuatum* (Klement) are emended. The species *Hystrichosphaeridium capitatum* Cookson & Eisenack is transferred to the genus *Tenua* (Eisenack), and the species *Gonyaulacysta evitti* Dodékova to the genus *Occisucysta* gen. nov.

Seven species are recorded for the first time from Europe. Comparison is made with previously described specimens from Australia, France, Germany and England. Assemblages from the Kimmeridgian are found to be very close to the Upper Callovian and the Oxfordian assemblages of England and Normandy. A comparison with the Australian assemblages shows differences between the size of Australian and of Western European specimens.

## I. INTRODUCTION

The Kimmeridge Clay is seen in its typical facies in Dorset, the outcrop extending northwards into the southern Midlands of England. It is located above the Corallian and it is overlain by the Portland Sands and Portland Stone.

In France, beds of equivalent age are seen in the Boulonnais; the north-west and south-west of the Paris Basin ; Normandy ; and the Rhône Valley (Text-figure 1).

The Boulonnais is the nearest part of the European continent to the British Isles ; the exposures there are therefore of particular interest from the viewpoint of establishing international correlation. These beds have been subdivided by Ager (1963) into the Argiles de Moulin Wibert, Calcaires de Moulin Wibert, Grès de Châtillon and Schistes de Châtillon. The Argiles de Moulin Wibert are the lowest Jurassic strata exposed on this coast and form the core of the Crèche Anticline.

In Normandy and Le Havre, the Lower Kimmeridgian is only represented beneath the unconformable Cretaceous by clays and limestones with ammonites indicative of the Mutabilis, Cymodoce and Baylei Zones. At the junction between Kimmeridgian and Oxfordian, there is a thin bed of clay full of *Liostrea delta* Smith, comparable with that at Ringstead, Dorset.

Upper Jurassic rocks are known from a number of localities in the Hebridean region. In Scotland, on the Isle of Skye, beds of Kimmeridgian age are known only at Trotternish. Exposures on the coast, from Staffin Bay northwards, show Kim-

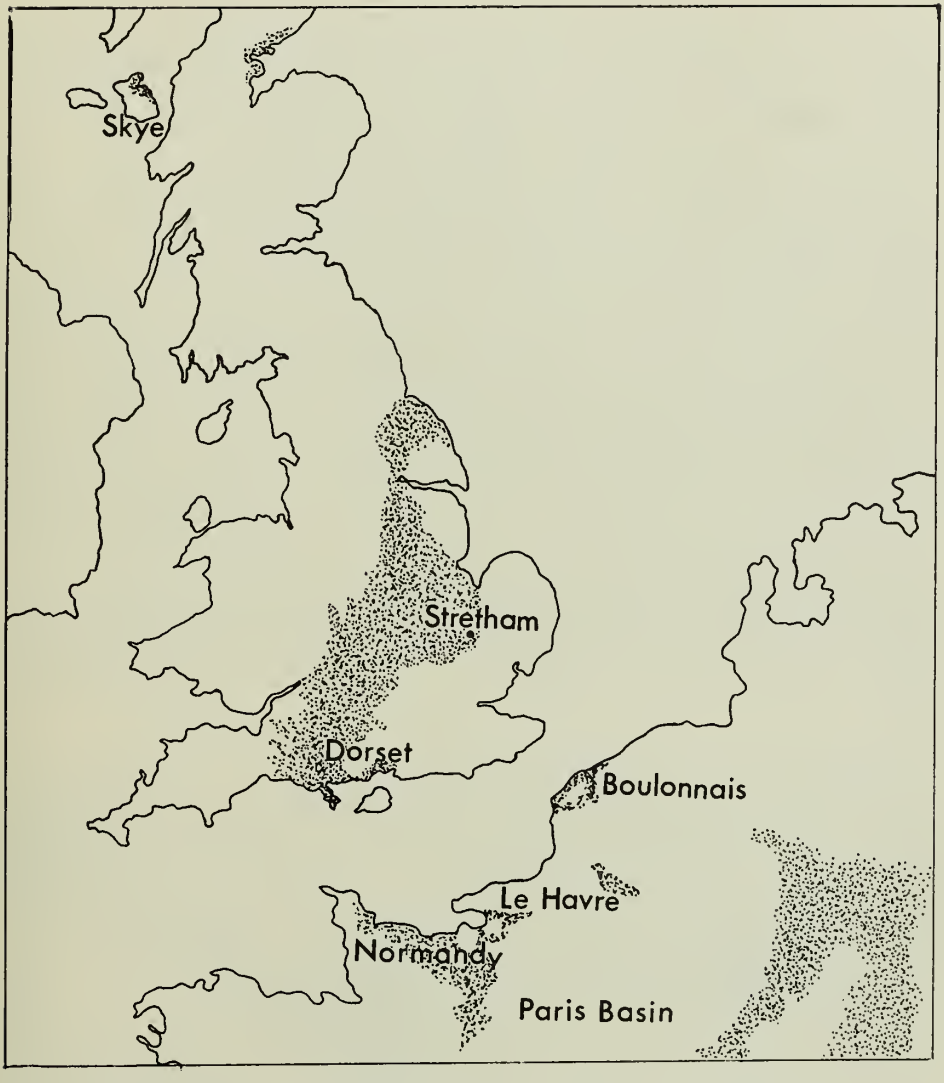


FIG. 1. Sketch map showing the Jurassic outcrops in England and Northern France, from which the samples were taken.

meridge Clay following the Corallian with little change in lithology. The ammonite fauna in the upper beds indicates the Baylei Zone.

Kimmeridgian microplankton were first described by Deflandre (1938); the first English assemblages were recorded by Downie (1957). Subsequently Lantz (1958) and Sarjeant (1960) gave incidental mention to Kimmeridgian forms.

Further research was considered necessary to increase our knowledge of the

Kimmeridgian microplankton. This is particularly so with respect to their potentiality as stratigraphical indicators in beds, whose subdivision and correlation present considerable difficulties. The plan of research adopted was to first of all examine assemblages from the type locality for the stage (Dorset), and then to examine comparative sections from regions to the north and south of this area, in order to assess the degree of lateral change in the assemblages.

This paper contains an account of the lowest zone (Baylei Zone) only. (The assemblages from higher zones will be described in a subsequent paper.)

Microplankton are here recorded for the first time from the Upper Jurassic of Scotland, the Boulonnais, Le Havre and the English Midlands.

*Stage divisions of the Upper Jurassic* : In 1962 the Jurassic system as a whole, and especially the Kimmeridgian–Portlandian boundary, was discussed at an International Colloquium held in Luxembourg. No firm decision was reached at this meeting, two alternative schemes being put forward. The first of the schemes was to retain the Kimmeridgian and the Portlandian in the sense of Arkell 1946; a second scheme visualized a short Kimmeridgian ending at the Gravesia Zone and followed by the Tithonian. The results of this meeting were discussed in papers published by D. V. Ager (1963), A. J. Lloyd (1964) and J. C. W. Cope, W. A. S. Sarjeant, D. A. E. Spalding and A. Zeiss (1963).

At a second meeting held in Luxembourg (1967), the problem of the Upper Jurassic stages was again discussed, but no firm decision was reached. For the present, it is here proposed to accept the Kimmeridgian in the original sense of d'Orbigny and of Arkell, i.e. commencing with the Baylei Zone and terminating with the Pallasioides Zone.

## II. MATERIAL AND LOCALITY

The fossil microplankton assemblage here described were all obtained from the argillaceous facies of the Kimmeridge Clay. The samples consisted of either grey clay, shaly clay, black clay or argillaceous limestones. Seven samples were examined from Dorset, one sample from Cambridgeshire, and three samples from Staffin Bay, Isle of Skye, Scotland. French samples were taken from three parts of France: Normandy (one sample), Le Havre (two samples) and the Boulonnais (seven samples). The Dorset samples were collected by Dr. W. A. S. Sarjeant and Dr. J. C. W. Cope. The samples from Le Havre and Normandy and those from the Boulonnais were collected by Dr. W. A. S. Sarjeant under the guidance of M. Michel Rioult and Dr. D. V. Ager respectively. Samples of Kimmeridge Clay from Staffin Bay were collected by Dr. W. A. S. Sarjeant and Mr. D. Field.

Samples are numbered according to the system suggested by Dr. W. A. S. Sarjeant ; duplicate samples are stored in his collections (University of Nottingham).

All samples were collected from the Baylei Zone of Kimmeridgian.

1. OM 131—shaly clay, light olive grey in colour (5 Y 4/1) at the base of Kimmeridge Clay. *Liostrea delta* Bed, foreshore exposure immediately west of the slipway at Osmington Mills, Dorset.[1] (National grid reference : 734817).

[1] Explanation of the samples colours are according to the " Rock Color Chart ", produced by the Geological Society of America (1963) and based on the Munsell System.

2. OM 418—clay, greenish grey in colour (5 GY 6/1), from 10 ft. above Ringstead Coral Bed. Foreshore exposure, west of Osmington Mills, Dorset.

3. OM 419—clay, dark grey in colour (5 G 4/1), from 15 ft. above Ringstead Coral Bed. Foreshore exposure, west of Osmington Mills, Dorset.

4. OM 420—clay, light grey in colour (N 7), from 20 ft. above Ringstead Coral Bed. Foreshore exposure, west of Osmington Mills, Dorset.

5. HD 191—clay, light greenish grey in colour (5 GY 7/1), from 6 ft. below top of the Black Clay, Holworth, Dorset. (National grid reference : 763817).

6. RB 218—clay, dark greenish grey in colour (5 G 4/1), from between the Ringstead Waxy Clay and the Ringstead Coral Bed, Ringstead Bay, Dorset. (National grid reference : 757814).

7. RB 219—clay, medium light grey in colour (N 6), from the *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset.

8. SC 444—clay, medium light grey in colour (N 6), from the Great Ouse River Board Pit, Stretham, Cambridgeshire. (National grid reference : 516743).

9. SS 625—shale, medium dark grey in colour (N 4), from 60 ft. above the second dolerite sill, Staffin Bay, east of Digg, Isle of Skye, Scotland. (National grid reference : 473696). (Pt. 2 in figure 2).

10. SS 626—shale, medium dark grey in colour (N 4), from 80 ft. above the second dolerite sill, Staffin Bay, east of Digg, Isle of Skye, Scotland.

11. SS 627—shale, between medium dark grey and dark grey in colour (N $3\frac{1}{2}$), from 100 ft. above the second dolerite sill, Staffin Bay, east of Digg, Isle of Skye, Scotland.

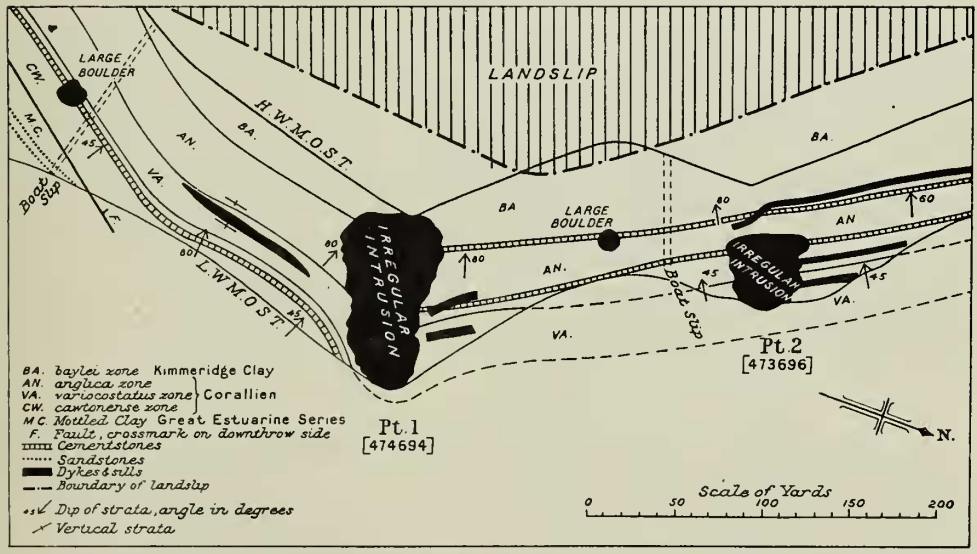


FIG. 2. Sketch map of Staffin Bay, coast of Digg, showing collection localities. (From " The Geology of Northern Skye ", Geological Survey Memoir, pp. 49, fig. 8. Reproduced by permission of the Director of the Institute of Geological Sciences.)

12. VN 184—clay, medium light grey in colour (N 6), from the *Liostrea delta* Bed (equivalent to that at Ringstead), Villerville, Normandy, France.

13. CH 185—clay, light grey in colour (N 7), from Exogyra Marls, *c.* 1 m. above the Upper Hard Band, Cap de La Hève, Le Havre, France.

14. CH 186—clay, light grey in colour (N 7), from immediately below Upper Hard Band, Cap de La Hève, Le Havre, France.

15. CC 447—clay, medium dark grey in colour (N 4), from the Argiles de Moulin Wibert, lowest exposed level (20 ft. below the top) on the south side of Cap de La Crèche, Boulonnais, France.

16. CC 448—clay, light grey in colour (N 7), from the base of the Calcaires de Moulin Wibert, south side of Cap de La Crèche, Boulonnais, France.

17. CC 449—clay, light grey in colour (N 7), from *c.* 10 ft. top of the Calcaires de Moulin Wibert, south side of Cap de La Crèche, Boulonnais, France.

18. CC 450—clay, light olive grey in colour (5 Y 6/1), from the top of the Grès de Châtillon, south side of Audresselles, Boulonnais, France.

19. CC 451—clay, dark grey in colour (N 3), from 5 ft. above the base of Argiles de Châtillon, south side of Audresselles, Boulonnais, France.

20. CC 452—clay, dark greenish grey in colour (5 GY 4/1), from 5 ft. below the base of Grès de La Crèche, south side of Audresselles, Boulonnais, France.

21. CC 455—clay, greenish grey in colour (5 GY 6/1), from beneath Upper Nodule Bed dividing Argiles de La Crèche from Argiles de Wimereux ; *c.* 200 yds. north of Cap de La Crèche, Boulonnais, France.

## III. TREATMENT

Every sample was cleaned first, then crushed mechanically and treated with 50% HCl acid to remove carbonates, washed to neutrality and then heated in HF acid of commercial strength. After being again washed to neutrality, the organic residue was heated in HCl acid and once more washed to neutrality. The residue was oxidized with Schulze solution and washed again ; to complete the maceration it was then treated with 10% NaOH solution, to remove humic compounds, and washed into a sintered glass filter funnel. After further washing with water the residue was stained with safranin. A small amount of the glycerine jelly was melted in a test tube and a few drops of the prepared sample in water suspension, added. The mixture was then vigorously agitated so as to disperse the microfossils. A drop of the solution was transferred, by a pipette, to a clean microscope slide and covered by a coverslip and allowed to dry for study.

## IV. SYSTEMATIC SECTION

The full list of species present, together with their numerical distribution, is given in Table 4 A and B.

Proportions of the major components of the assemblage are given in Tables 1, 2 and 3.

The cysts are shown to fall into three broad groups, " proximate ", " chorate " and " cavate ", which are interpreted as indicating different modes of formation within the cell wall of the motile dinoflagellate. Only species that are new, or

species about which additional information can be given, are dealt with in this section.

All type specimens and some of the figured specimens that are mentioned together with the British Museum (Natural History) slide numbers, are deposited in the Palaeontological collections of the British Museum (Natural History), London. The rest of the figured specimens and other representative slides are lodged in the collections of the Micropalaeontology Laboratory, Department of Geology, University of Nottingham.

TABLE 1

Proportion of the major components of the assemblages from England

| | No. of samples examined | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Microfossil groups | OM 131 | OM 418 | OM 419 | OM 420 | HD 191 | RB 218 | RB 219 | SC 444 |
| | % | % | % | % | % | % | % | % |
| ACRITARCHA | | | | | | | | |
| Micrhystridia | 0·2 | 6·8 | 1·3 | 6·5 | 2·8 | 3·2 | 1·1 | 20·9 |
| Total Acritarcha | 5·4 | 11·8 | 4·0 | 15·4 | 8·5 | 14·2 | 9·4 | 24·8 |
| DINOPHYCEAE | | | | | | | | |
| Proximate cysts | 33·1 | 37·2 | 35·6 | 45·8 | 17·4 | 24·3 | 35·3 | 21·3 |
| Chorate cysts | 12·2 | 20·5 | 12·1 | 8·4 | 2·8 | 33·3 | 8·0 | 2·8 |
| Proximochorate cysts | 0·2 | — | 0·4 | 1·7 | — | — | — | 0·5 |
| Cavate cysts | 11·2 | 9·3 | 9·9 | 13·6 | 2·8 | 2·5 | 1·1 | 2·1 |
| Indeterminate cysts | 8·1 | 8·0 | 10·3 | 8·3 | 42·8 | 5·2 | 13·2 | 2·5 |
| Total Dinoflagellates | 64·8 | 75·0 | 68·3 | 77·8 | 65·5 | 65·0 | 57·4 | 29·2 |
| Pollen and Spores | 29·0 | 13·2 | 25·4 | 6·8 | 25·7 | 20·5 | 28·1 | 36·0 |
| Foraminiferal shell linings | — | — | 2·3 | — | — | — | — | 10·0 |
| Wood fragments | 0·8 | — | — | — | — | — | 4·9 | — |

TABLE 2

Proportion of the major components of the assemblages from Scotland

| | No. of samples examined | | |
|---|---|---|---|
| Microfossil groups | SS 625 | SS 626 | SS 627 |
| | % | % | % |
| ACRITARCHA | | | |
| Micrhystridia | 0·5 | 0·8 | 1·4 |
| Total Acritarcha | 2·9 | 1·0 | 2·2 |
| DINOPHYCEAE | | | |
| Proximate cysts | 25·7 | 11·4 | 20·1 |
| Chorate cysts | 7·9 | 3·9 | 9·2 |
| Proximochorate cysts | — | 0·2 | 0·2 |
| Cavate cysts | 5·1 | 1·9 | 3·8 |
| Indeterminate cysts | 2·3 | 1·5 | 4·5 |
| Total Dinoflagellates | 41·1 | 18·9 | 37·8 |
| Pollen and Spores | 39·0 | 76·1 | 56·0 |
| Foraminiferal shell linings | 13·0 | 2·0 | 3·0 |
| Wood fragments | 4·0 | 2·0 | 1·0 |

TABLE 3

Proportion of the major components of the assemblages from France

| Microfossil groups | No. of samples examined | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | VN 184 | CH 185 | CH 186 | CC 447 | CC 448 | CC 449 | CC 450 | CC 451 | CC 452 | CC 455 |
| | % | % | % | % | % | % | % | % | % | % |
| ACRITARCHA | | | | | | | | | | |
| Micrhystridia | 3·0 | 5·1 | 2·2 | 1·4 | 1·8 | 0·6 | 1·0 | — | — | — |
| Total Acritarcha | 11·9 | 13·1 | 2·7 | 12·0 | 8·2 | 3·4 | 2·0 | 35·7 | — | — |
| DINOPHYCEAE | | | | | | | | | | |
| Proximate Cysts | 30·3 | 39·1 | 41·2 | 28·4 | 36·5 | 54·3 | 45·7 | 9·9 | 55·6 | 7·0 |
| Chorate cysts | 27·2 | 7·2 | 7·8 | 38·7 | 5·7 | 19·5 | 4·8 | 19·1 | 20·5 | 0·8 |
| Proximochorate cysts | 0·6 | — | — | — | — | — | — | — | — | — |
| Cavate cysts | 14·1 | 4·4 | 21·1 | 6·5 | 18·1 | 4·2 | 8·3 | 3·9 | 0·6 | 7·7 |
| Indeterminate cysts | 7·9 | 9·2 | 7·2 | 6·4 | 12·0 | 14·6 | 10·2 | 19·1 | 12·8 | 11·5 |
| Total Dinoflagellates | 80·1 | 59·9 | 77·3 | 80·0 | 72·3 | 92·6 | 69·0 | 52·0 | 89·5 | 27·0 |
| Pollen and Spores | 8·0 | 27·0 | 20·0 | 8·0 | 18·0 | 3·0 | 29·0 | 12·3 | 10·5 | 73·0 |
| Foraminiferal shell linings | — | — | — | — | — | 1·0 | — | — | — | — |
| Wood fragments | — | — | — | — | 1·5 | — | — | — | — | — |

Class *DINOPHYCEAE* Pascher

Sub-class *DINOFEROPHYCIDAE* Bergh

Order DINOPHYCIALES Lindemann

Cyst-Family **FROMEACEAE** Sarjeant & Downie, 1966

Genus ***CHYTROEISPHAERIDIA*** Sarjeant, emend. Downie, Evitt & Sarjeant, 1963

***Chytroeisphaeridia chytroeides*** Sarjeant, 1962b

(Pl. 14, fig. 5)

1962b *Leiosphaeridia* (*Chytroeisphaeridia*) *chytroeides* Sarjeant, 493–494, pl. 70, figs. 13, 16 ; text-figs. 11, 12, tables 2, 3.
1963 *Chytroeisphaeridia chytroeides* (Sarjeant) ; Downie, Evitt & Sarjeant: 9.
1964 *C. chytroeides* (Sarjeant) ; Downie & Sarjeant: 103.
1967a *C. chytroeides* (Sarjeant) ; Sarjeant, table 3.
1968 *C. chytroeides* (Sarjeant) ; Sarjeant, pl. 3, fig. 10, table 2B.

This species has been previously recorded from the Oxfordian (Ampthill Clay) of England by Sarjeant (1962). It occurs in moderate abundance in the assemblages from the base of the Kimmeridgian of England, Scotland and France.

FIGURED SPECIMEN. BM(NH) slide V.53975(1). Shale from 80 ft. above the second dolerite sill, east of Digg, Staffin Bay, Skye (SS 626).

DIMENSIONS. There is a difference in range of dimensions between Oxfordian and

Kimmeridgian specimens: Diameters of Oxfordian specimens, as quoted by Sarjeant, are between 30–60 μ ; figured specimen's length (apex lacking) 45 μ, breadth 55 μ. Range of the measured specimens: length (apex lacking) 20–65 μ, breadth 18–75 μ. 154 specimens were measured.

### *Chytroeisphaeridia pococki* Sarjeant, 1968

(Pl. 9, figs. 7, 8; Pl. 10, fig. 3)

1965 *Chytroeisphaeridia* sp. Sarjeant, pl. 1, fig. 13.
1968 *Chytroeisphaeridia pococki* Sarjeant, 230, pl. 3, fig. 9.

*Chytroeisphaeridia pococki* has been previously observed in both the Lower Callovian (*S. calloviense* Zone) and Upper Callovian (*L. lamberti* Zone) of Normandy by Sarjeant (1965, 1968). It has also been recorded from the base of Kimmeridgian of England, Scotland and France.

Figured specimens. BM(NH) slide V.53958(2). Clay from 20 ft. above Ringstead Coral Bed, west of Osmington Mills, Dorset (OM 420).

BM(NH) slide V.53619(1). Shale from 100 ft. above the second dolerite sill, Staffin Bay, Skye (SS 627).

BM(NH) slide V.53954(1). Clay from 10 ft. above the Ringstead Coral Bed, west of Osmington Mills, Dorset (OM 418).

Dimensions. The observed range in dimensions was length (apex lacking) 30–80 μ, breadth 30–70 μ; somewhat larger than those of the holotype (holotype dimensions, quoted by Sarjeant: length -apex lacking- 45 μ, breadth 55 μ.). 32 specimens were measured.

### Genus *TENUA* Eisenack, emend. Sarjeant, 1968

### *Tenua* cf. *capitata* (Cookson & Eisenack), comb. nov.

(Pl. 10, fig. 4)

*Hystrichosphaeridium capitatum* has previously been recorded from the Oxfordian to the Kimmeridgian of Australia by Cookson and Eisenack. This species is placed in the genus *Tenua* on the basis of the shell outline, the presence of an apical archaeopyle, and the form and number of the processes. The distribution of the processes of this species does not reflect any tabulation ; also since they exceed 30, they are not the right number for the genus *Hystrichosphaeridium*.

Description. *Tenua* cf. *capitata* has a subspherical to elongate shell with an apical archaeopyle. It bears processes whose length is about one third of the shell breadth and up to fifty in number. The processes are hollow, capitate or somewhat bifurcate, their distribution appearing at random.

Figured specimen. BM(NH) slide V.53947(1). Clay from the base of Kimmeridge Clay, Ringstead Bay, Dorset (RB 219).

DIMENSIONS. Figured specimen: shell length (apex lacking) 50 μ, breadth 28 μ ; process length 7–9 μ. Range of the English specimens (6 specimens measured) : shell length 65 μ (apex lacking 50–57 μ), breadth 22–52 μ ; process length 7–10 μ ; French specimens (2 specimens measured) : shell length (apex lacking) 30–33 μ, breadth 25–40 μ ; process length 5–7 μ. These dimensions are similar to the dimensions of the Australian specimens (as quoted by Cookson and Eisenack : length 64–66 μ, breadth 28–44 μ).

REMARKS. Well-preserved specimens were observed in moderate number in the assemblages from Dorset, Le Havre and the Boulonnais. They are similar to the specimen figured by Cookson and Eisenack, but differ from it in the length and the number of the processes, the basal Kimmeridgian specimens having longer processes in greater number.

### ***Tenua hystrix*** Eisenack, 1958

(Pl. 5, fig. 8 ; Pl. 10, fig. 7)

1958 *Tenua hystrix* Eisenack: 410, pl. 23, figs. 1–4 ; text-fig. 10.
1961a *T. hystrix* Eisenack ; Evitt: 398, pl. 1, fig. 2 ; pl. 5, fig. 1.
1964 *T. hystrix* Eisenack ; Downie & Sarjeant: 148.
1967a *T. hystrix* Eisenack ; Sarjeant, table 3.

*Tenua hystrix* has been recorded from the Aptian of Germany by Eisenack (1958). It is common in English, Scottish and French materials studied.

FIGURED SPECIMENS. BM(NH) slide V.53947(2). Clay from *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset (RB 219) para. BM (NH) slide V.52794(2). Shaly clay from the base of Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

DIMENSIONS. Range of the dimensions : length (apex lacking) 35–80 μ, breadth 25–62 μ ; length of the spines 3–8 μ. 28 specimens were measured.

### ***Tenua pilosa*** (Ehrenberg) emend. Sarjeant, 1968

(Pl. 4, fig. 5)

1843 *Xanthidium pilosum* Ehrenberg: 61–63.
1854 *X. pilosum* Ehrenberg ; Ehrenberg, pl. 37, fig. 8, no. 4.
1904 *Ovum hispidum* (*Xanthidium*) *pilosum* (Ehrenberg) ; Lohmann: 24–25.
1937 *Hystrichosphaeridium pilosum* (Ehrenberg) ; Deflandre: 31.
1960 *Baltisphaeridium pilosum* (Ehrenberg) ; Sarjeant, pl. 13, figs. 11, 12.
1961a *B. pilosum* (Ehrenberg) ; Sarjeant: 101–102, pl. 14, figs. 3–5.
1962a *B. pilosum* (Ehrenberg) ; Sarjeant, pl. 20, figs. 7–10 ; tables. 3, 4.
1964 *B. pilosum* (Ehrenberg) ; Downie & Sarjeant: 94.
1964a *B. pilosum* (Ehrenberg) ; Sarjeant, table 3.
1966 *Cleistosphaeridium pilosum* (Ehrenberg) ; Davey, Downie, Sarjeant & Williams, *nomen nudum*: 170.
1967a *Tenua pilosa* (Ehrenberg) ; Sarjeant, table 3.
1968 *T. pilosa* (Ehrenberg) ; Sarjeant: 231, pl. 2, fig. 7.
1969 *T. pilosa* (Ehrenberg) ; Davey, Downie, Sarjeant & Williams (in press).

This species of *Tenua* has been recorded from the Upper Callovian (*L. lamberti* Zone) and Oxfordian in Europe. Well preserved specimens were observed in the base of Kimmeridgian.

FIGURED SPECIMEN : BM(NH) slide V.52793(1). Shaly clay from immediately west of the slipway at Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : length 50 $\mu$, breadth 40 $\mu$ ; length of the spines 6–8 $\mu$. Range of the dimensions : English specimens length 40–70 $\mu$, breadth 50 $\mu$ ; Scottish specimens length 35–40 $\mu$, breadth 30–45 $\mu$ ; French specimens length 60 $\mu$, breadth 50 $\mu$. In all specimens, the length of the spines was 3–8 $\mu$. 10 English, 1 French and 7 Scottish specimens were measured.

## *Tenua* sp.

(Pl. 9, fig. 3 ; Text-fig. 3)

DESCRIPTION. The spherical shell possesses spines that are uniformly distributed over the whole surface. These spines are very short, solid and conical. Neither tabulation nor longitudinal or transverse structure were seen. There is a large apical archaeopyle; however, the operculum remains attached on one side. Surface smooth between the spines. Spines are numerous, about 220.

FIGURED SPECIMEN. BM(NH) slide V.52796(1). Shaly clay from the base of Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

DIMENSIONS. Overall length 50 $\mu$, breadth 50 $\mu$ ; apex lacking length 43 $\mu$ ; length of the spines 2 $\mu$.

REMARKS. A single specimen was observed in the Dorset material, which is

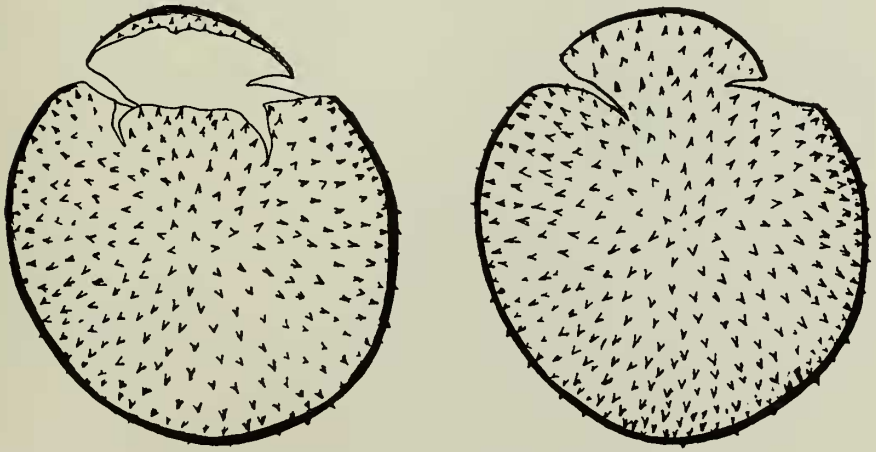

FIG. 3. *Tenua* sp. General appearance and the apical archaeopyle formation (the operculum remains attached on one side). $\times c.$ 1280.

different from previously described species of *Tenua*, in its characteristic shape and spines. It may represent a new species, but further and better specimens are required before this can be decided.

## Cyst-Family ***GONYAULACYSTACEAE*** Downie & Sarjeant, 1966

## Genus ***CRYPTARCHAEODINIUM*** Deflandre, emend.

EMENDED DIAGNOSIS. Proximate dinoflagellate cysts, spherical, subspherical, broadly ovoidal or polygonal, with tabulation : 4′, 0–1a, 6″, 6c, 7″ ′, 2p, 0–1pv and 1″ ″. Cingulum almost equatorial and slightly or strongly helicoid, laevorotatory. Sulcus generally broad, extending onto both epitract and hypotract. Apical horn rarely present ; median and antapical horns lacking. Sutures in the form of low ridges ; bearing crests of denticulate or spinous type. Archaeopyle formation, where developed, precingular and formed by loss of plate 3″.

TYPE SPECIES. *Cryptarchaeodinium calcaratum* Deflandre 1939. Upper Jurassic (Kimmeridgian) ; France.

REMARKS. The generic diagnosis is emended to include reference to the tabulation, to the apical horn and to the mode of archaeopyle formation.

This genus, in view of inadequate knowledge of its morphology and in particular of its mode of archaeopyle formation was not attributed to any of dinoflagellate cyst-families, but was mentioned under " Cyst-Family Uncertain " by Downie & Sarjeant (1966). Since it has a tabulation of *Gonyaulax* type and a precingular archaeopyle, it is possible to reattribute this genus to the Cyst-Family *Gonyaulacystaceae*.

## ***Cryptarchaeodinium calcaratum*** (Deflandre), emend.

(Pl. 1, figs. 1, 2 ; Text-fig. 4)

1939 *Cryptarchaeodinium calcaratum* Deflandre: 145, pl. 6, fig. 6.
1941 *C. calcaratum* Deflandre ; Deflandre: 19, pl. 5, figs. 7–9 ; text-figs. 9–10.
1952 *C. calcaratum* Deflandre ; Deflandre, fig. 92.
1964 *C. calcaratum* Deflandre ; Downie & Sarjeant: 104.
1964 *C. calcaratum* Deflandre ; Eisenack: 153–154.
1964a *C. calcaratum* Deflandre ; Sarjeant, table 2.
1967a *C. calcaratum* Deflandre ; Sarjeant, table 4.

EMENDED DIAGNOSIS. A *Cryptarchaeodinium* having a small, almost spherical shell, without either an apical or antapical process. Tabulation: 4′, 6″, 6c, 7″ ′, 2p, 1″ ″. Plate boundaries bear short spiny crests. Cingulum almost equatorial, strongly spiral, laevorotatory. Shell wall thin, surface granular. Large precingular archaeopyle formed by loss of plate 3″.

HOLOTYPE. Specimen AP 17, Deflandre coll., Ecole Pratique des Hautes Etudes, Paris ; from Kimmeridgian of Orbagnoux, France.

FIGURED SPECIMEN. BM(NH) slide V.53959(1). Clay from Great Ouse River Board Pit, Stretham, Cambridgeshire (SC 444).

Dimensions. Holotype : overall length 40 $\mu$, breadth 40 $\mu$ ; length of the spines 3 $\mu$. Figured specimen : overall length 34 $\mu$, breadth 33 $\mu$ ; spines length 2–3 $\mu$.

Description. Theca almost spherical, but having a somewhat polygonal appearance because of the angularly set spine rows on the plate boundaries.

Four apical plates are present. Plate 1′ is the largest ; the boundary between plates 1′ and 4′ was not clear. The six precingular plates, together with the apical plates form the epitract ; there is no anterior intercalary plate. Plate 1″ is reduced to accommodate of plate 2′. Plates 2″, 3″, 4″ and 5″ are more or less uniform in size and shape, but plate 6″ is different in shape because of the broadening sulcus.

The cingulum is occupied by six plates of moderate size. The sulcus extends onto

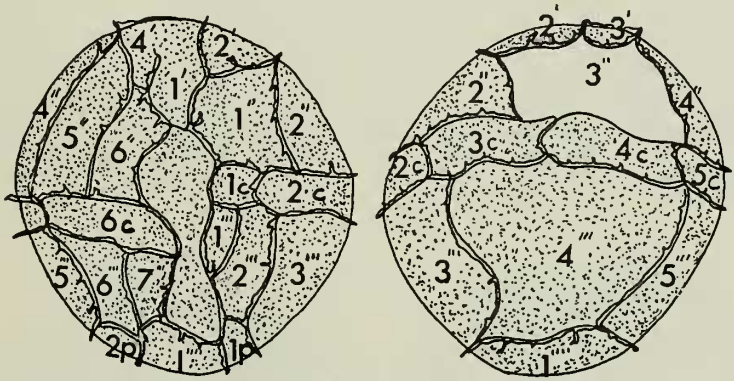


Fig. 4. *Cryptarchaeodinium calcaratum* (Deflandre). Specimen, showing the tabulation and the precingular archaeopyle (plate 3″ is missing). Left, ventral view; right, dorsal view. ×*c.* 1400.

the epitract and the hypotract, from apex to antapex ; it is narrow in its middle portion, being broad in its anterior and posterior portions.

Seven postcingular plates of variable size and shape are present. Plates 1‴′, 6‴′ and 7‴′ are small, whereas plate 4‴′ is largest of all the plates of the shell. Two posterior intercalary plates are located on the two sides of the posterior end of the sulcus. The single antapical plate 1‴′ is a rather small plate.

Remarks. The diagnosis of *C. calcaratum* is emended to include the presence of the archaeopyle and the detail of the tabulation. This study was based on a single but excellently preserved specimen from the Kimmeridge Clay of Stretham.

Deflandre first observed *C. calcaratum* in the assemblages from Orbagnoux in 1939 ; a fuller diagnosis was given in 1941 and quoted again in 1952. The Stretham specimen corresponds closely to the holotype, differing only in the number of the apical plates, which are hesitantly mentioned as 4 in number by Deflandre (1941), and in the presence of the precingular archaeopyle.

In 1957, Downie observed a very similar specimen in the Kimmeridge Clay of Dorset, which he mentioned and figured as *Cryptarchaeodinium* sp. Although it was similar in many respects to this genus, it differed in the presence of an anterior inter-

calary plate 1a and of several very small plates between the plates 1a and 6″. The position of the antapical plate 1″ ″ and the sutures were also different. Eisenack incorrectly cited Downie's species as *C. calcaratum* in his " Katalog der Fossilen Dinoflagellaten, Hystrichosphären und verwandten Mikrofossilen " in 1964. On the basis of Downie's figure and description, this is unjustified.

### *Cryptarchaeodinium* sp.

(Pl. 6, figs. 4, 7 ; Text-fig. 5)

Description. A small shell, spherical with a short and broad, blunt apical horn. The cingulum is slightly laevorotatory, dividing the theca into two unequal parts with epitract larger than the hypotract. Both cingulum and sulcus are broad. Reflected tabulation : 4′, 1a, 6″, 6c, 7″ ′, 2p, 1pv and 1″ ″. Apical plate 1′ is elongate, as long as the sulcus, and extends along the anterior prolongation of the sulcus. The other apical plates are small. The single anterior intercalary plate 1a is large and nearly square. The precingular plates are relatively large, plate 6″ being reduced to accommodate the intercalary plate 1a.

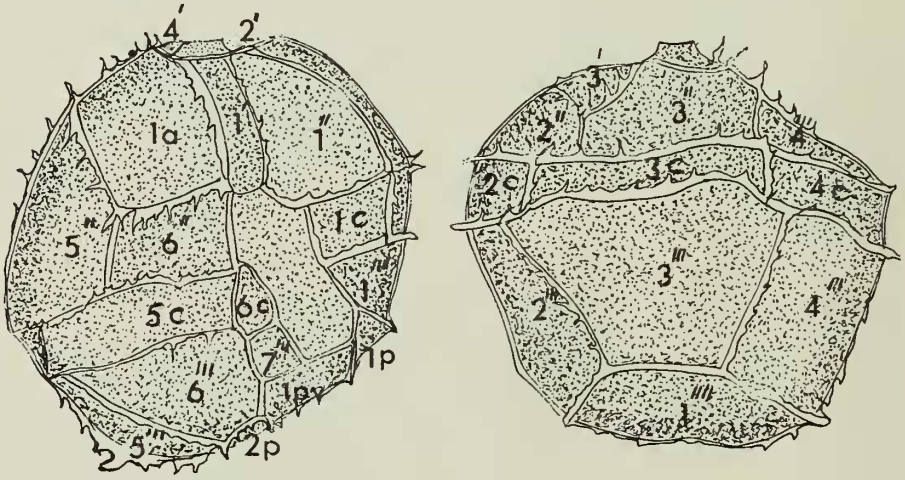


Fig. 5. *Cryptarchaeodinium* sp. Tabulation. Left, ventral view ; right, dorsal view. ×*c.* 1280.

Six plates make up the cingulum: plate 6c is very small, triangular in shape.

Seven postcingular plates, with three intercalary plates and an antapical plate from the hypotract. Plate 1″ ′ is small ; plates 2″ ′, 3″ ′, 4″ ′, 5″ ′ and 6″ ′ are relatively large; plate 7″ ′ is again rather small. The posterior intercalary plate 1pv is large and situated posterior to the sulcus and plate 7″ ′ ; this position is unusual, since similar plates in other species are normally confined to the posterior extension of the sulcus. The other posterior intercalary plates (1p and 2p) are small ; the single antapical plate 1″ ″ is, in contrast, rather large.

Denticulate crests rise up on the plate boundaries. The surface of the shell is finely but densely granular.

Archaeopyle formation was not observed.

FIGURED SPECIMEN. BM(NH) slide V.53972(2). Clay from Grès de Châtillon, south of Audresselles, Boulonnais (CC 450).

DIMENSIONS. Figured specimen : overall length 40 $\mu$, breadth 40 $\mu$ ; horn length 3·5 $\mu$, breadth 5 $\mu$ ; cingulum 4–7 $\mu$ wide ; crests 4–8 $\mu$ high.

REMARKS. Although represented by a single specimen, the clear characterization of this form distinguishes it from the described species of *Cryptarchaeoidinium*. It is probably a new species, but further specimens are required to confirm this.

Hitherto two forms of *Cryptarchaeodinium* were known ; both were from the Kimmeridgian. This form has a small apical horn. It differs from *C. calcaratum* in the number and the shapes of the plates, in the presence of plate 1a and the absence of the archaeopyle. The absence of the small plates on the epitract and the presence of the posterior intercalary plates on the hypotract differentiate it from *Cryptarchaeodinium* sp. Downie, 1957.

## Genus ***GONYAULACYSTA*** Deflandre, emend. Sarjeant, 1969

### ***Gonyaulacysta aculeata*** (Klement) Sarjeant, 1969

(Pl. 1, figs. 5, 6 ; Text-figs. 6a, b)

1960 *Gonyaulax aculeata* Klement: 42, pl. 5, figs. 6, 7; text-fig. 21.
1964 *G. aculeata* Klement ; Downie & Sarjeant: 113.
1964 *G. aculeata* Klement ; Eisenack: 313.
1964a *G. aculeata* Klement ; Sarjeant, table 2.
1966 *Gonyaulacysta aculeata* (Klement) ; Sarjeant, *nomen nudum*: 130.
1967b *Gonyaulax aculeata* Klement ; Vozzhennikova, table 11.
1967b *Gonyaulacysta aculeata* (Klement) ; Sarjeant, *nomen nudum*, table 1.
1969 *G. aculeata* (Klement) ; Sarjeant (in press).

DESCRIPTION. Specimens of *G. aculeata* from the base of Kimmeridgian possess an ovate shell, with the tabulation : 4′, 6″, 6c, 6″ ′, 1p and 1″ ″. The epitract and hypotract are more or less equal in size and separated by the laevorotatory cingulum. The sulcus is broader on the hypotract. Longer spines, which are longer than the sutural spines, occupy the apex ; one of them is particularly prominent and forms the so-called " apical protuberance " mentioned by Klement. The sutures are marked by rows of spines. The spines are mostly simple and acuminate, but they become complicated near the apex and the antapex. The surface of the shell is coarsely tuberculate. A precingular archaeopyle is formed by loss of plate 3″.

FIGURED SPECIMEN. BM(NH) slide V.53965(3). Clay from Argiles de Moulin Wibert, lowest exposed level (20 ft. below the top) on the south side of Cap de La Crèche, Boulonnais (CC 447).

DIMENSIONS. Figured specimen : overall length 68 $\mu$, breadth 50 $\mu$ ; apical processes 6 $\mu$ long ; length of the spines on the sutures 3–5 $\mu$. Range of the other

specimens : English specimen (1 specimen measured) : length 63 $\mu$, breadth 55 $\mu$ ; spine length 3 $\mu$. French specimens (3 specimens measured) : length 68–74 $\mu$, breadth 63–65 $\mu$ ; length of apical processes 5–7 $\mu$ ; length of the spines 3–4 $\mu$. Range of German specimens, as quoted by Klement : length 66–72 $\mu$, breadth 61–63 $\mu$ ; length of the apical processes 6 $\mu$, sutural spines length 4 $\mu$.

Remarks. *G. aculeata* has been previously recorded from the Malm Upper Alpha

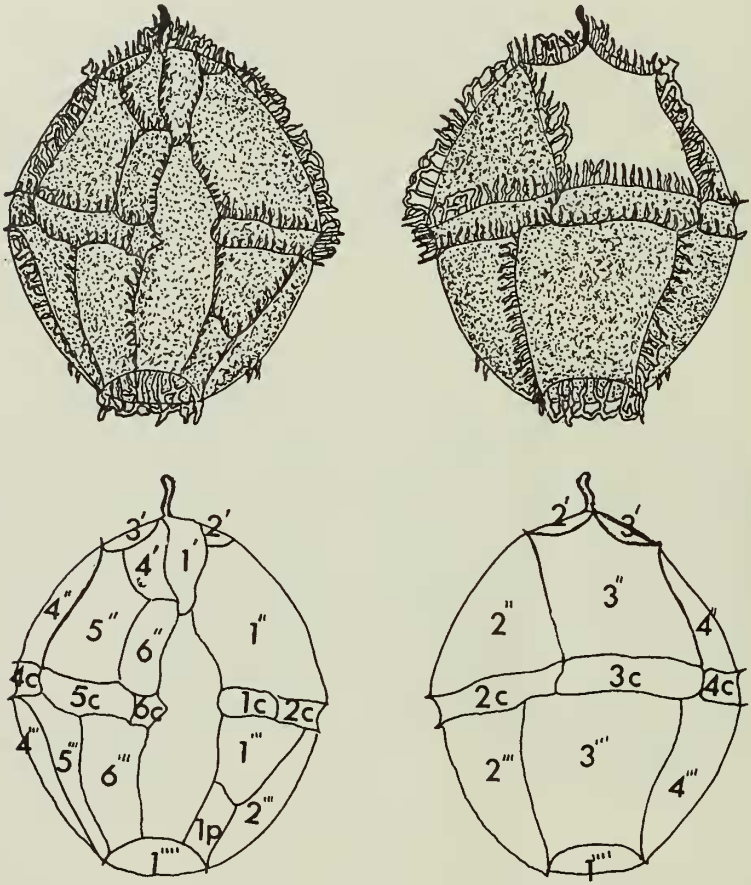


Fig. 6. *Gonyaulacysta aculeata* (Klement). A. General appearance and the archaeopyle formation ; left, ventral view ; right, dorsal view. ×*c.* 820. B. Tabulation. ×*c.* 820.

to Lower Delta of Germany by Klement (1960). It is rare in the assemblages from the base of Kimmeridgian ; the specimens are usually badly preserved. The basal Kimmeridgian specimens correspond closely to those figured from Germany, but plate 1ppl, which was mentioned by Klement, was not observed.

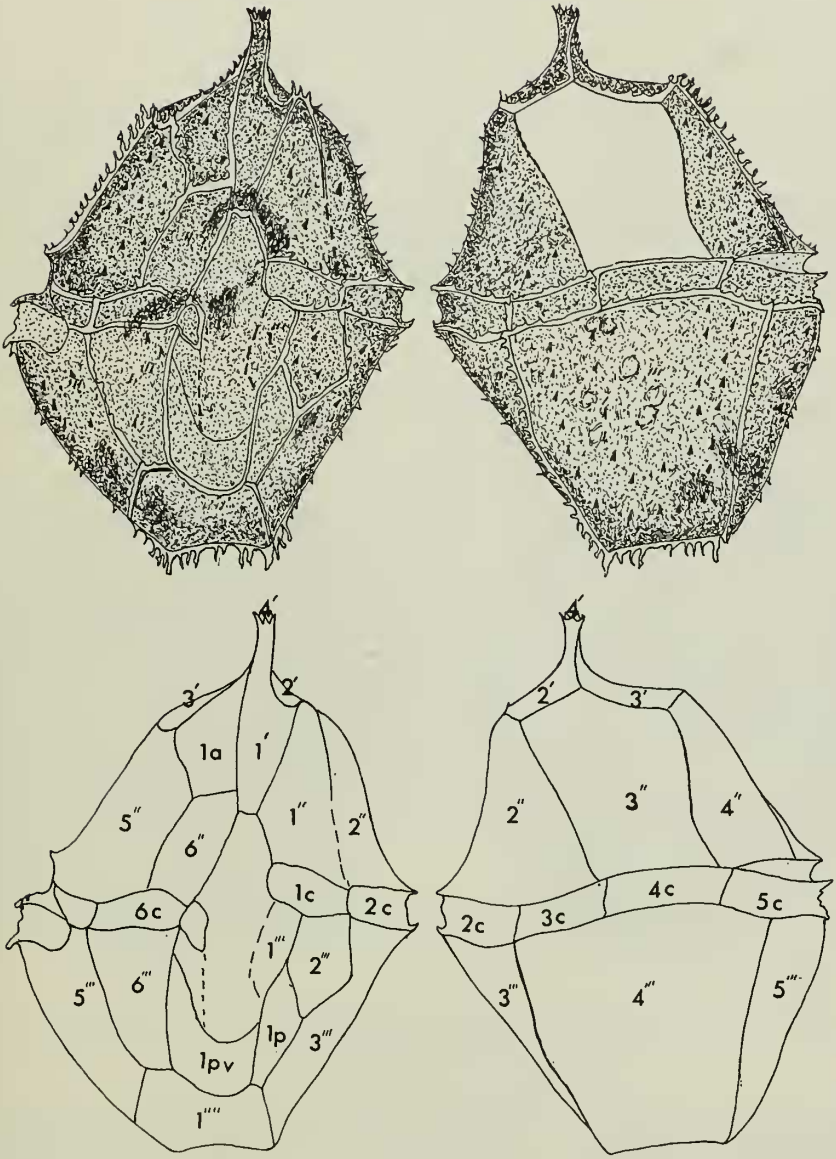


FIG. 7. *Gonyaulacysta angulosa* sp. nov. A. General appearance and the archaeopyle formation of the holotype. Left, ventral view ; right, dorsal view. ×*c.* 1280. B. Tabulation. ×*c.* 1280.

### *Gonyaulacysta angulosa* sp. nov.

(Pl. 2, figs. 4, 5 ; Text-fig. 7 a, b)

Derivation of the name. Latin, *angulosus*, angular, in reference to the shape of the cyst.

Diagnosis. *Gonyaulacysta* with a thick wall, composed of two layers ; the polygonal theca terminates in a strong apical horn formed from both shell layers. Tabulation : 4′, 1a, 6″, 6c, 6″ ′, 1p, 1pv, 1″ ″. Plates are bordered by denticulate crests of moderate height. Cingulum laevoratotory. Sulcus broad, extending onto both parts of the shell. Surface granular ; simple, solid, short spines occasionally present. Single-plate precingular archaeopyle forms by loss of plate 3″.

Holotype. BM(NH) slide V.53934(1). Clay from the *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Holotype : overall length 75 μ, breadth 58 μ ; horn length 7 μ, breadth 3 μ. Range of the dimensions : overall length 65–75 μ, breadth 50–58 μ ; horn length 6–8 μ. Measured specimens 3 in number.

Description. The elongate shell bears an apical horn which is developed from the apical plates 1′, 2′ and 3′ ; plate 4′ is placed on the top of the horn. Epitract is slightly longer than the hypotract. The nearly square anterior intercalary plate 1a is located between plates 3′ and 6″. Precingular plates are relatively large.

Six postcingular plates are present, with plates 1″ ′ and 2″ ′ reduced and angular in shape ; an elongate posterior intercalary plate between them and antapex. Plate 4″ ′ is very large and occupies nearly the whole dorsal side of the hypotract. A single, rather quadrate plate is present on the antapex; this antapical plate is separated from the sulcus by a crescent-shaped posterior ventral intercalary plate (1pv).

Remarks. This is an infrequent species : of four specimens encountered, one (holotype) is well preserved, the other three are severely damaged.

This new species, in general appearance, structure and the tabulation, agrees with those of the genus *Gonyaulacysta*.

*G. angulosa* may be compared with *G. cladophora* because of the structure of the sutures; but the tabulation, with plates 1a, 1pv, details of the plates 4′ and 1″ ″ and presence of the small sulcal plates, is different.

### *Gonyaulacysta ehrenbergii* sp. nov.

(Pl. 2, figs. 8, 9 ; Text-fig. 8)

Derivation of the name. Named after the microscopist Christian Gottfried Ehrenberg, who first discovered dinoflagellates in Jurassic and Cretaceous cherts and flints.

Diagnosis. *Gonyaulacysta* having an ovoidal theca of moderate wall thickness, with an apical horn. Tabulation : 4′, 1a, 6″, 6c, 7″ ′, 1p, 1pv, 1″ ″ ; sutures in form of moderately high, membraneous crests giving rise occasionally to short, blunt spines.

Cingulum narrow, helicoid, laevorotatory ; sulcus of moderate breadth. Shell surface densely granular. Large precingular archaeopyle formed by loss of plate 3″.

Holotype. BM(NH) slide V.53968(1). Clay from the base of the Calcaires de Moulin Wibert, south side of Cap de La Crèche, Boulonnais (CC 448).

Dimensions. Holotype : overall length 70 μ, breadth 50 μ ; horn length 8 μ ; breadth of the cingulum 5–8 μ. Range (5 specimens measured) : overall length 70–80 μ, breadth 50–65 μ ; horn length 6–9 μ.

Description. The shell is broadly ovoidal, giving rise to a strong apical horn ; this is formed by three of the four apical plates (plates 1′, 2′ and 4′). Apical plates 1′ and 4′ are larger than the other two plates ; 1′ is elongate. The single anterior intercalary plate 1a is large and located between the apical plates 3′, 4′ and precingular

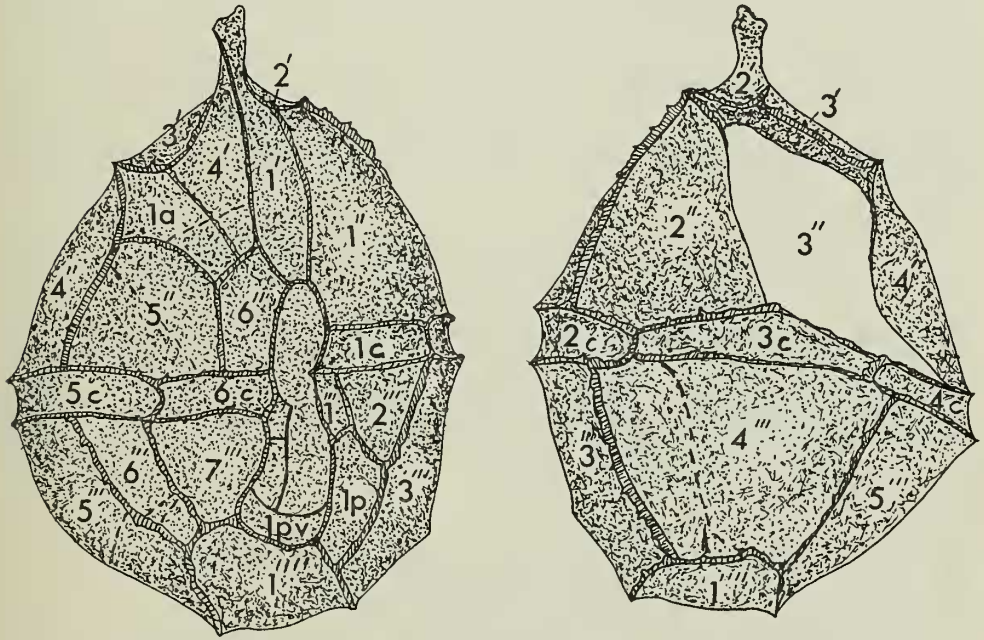


Fig. 8. *Gonyaulacysta ehrenbergii* sp. nov. Tabulation and the archaeopyle formation of the holotype (plate 3″ is missing). Left, ventral view ; right, dorsal view. ×*c.* 1200.

plates 4″, 5″, 6″. The precingular plates are generally large, plates 5″ and 6″ being reduced to accommodate the intercalary plate 1a.

Seven postcingular plates are present : Plates 1‴ and 2‴ are reduced because of the large intercalary plate 1p ; plates 6‴ and 7‴ are also reduced, since the large antapical plate 1‴ occupies a large area. The presence of posterior intercalary plate 1pv and the sulcal plates render the sulcus short and narrow.

Remarks. Five specimens of this infrequent species were observed ; all of them

are well preserved. All records were from French assemblages—from Normandy, and the Boulonnais.

The generic allocation of *Gonyaulacysta ehrenbergii* is questionable, in view of its possession of a seventh postcingular plate. The similarity in general morphology to a number of species of *Gonyaulacysta* resulted in its allocation to that genus. Since it possesses seven postcingular plates, there is a similarity between this species and the species of *Cryptarchaeodinium* ; but the *Cryptarchaeodinium* species so far observed have a slightly different tabulation, with plate 2p and without the sulcal plates. One species of that genus, described for the first time in this paper, bears a blunt apical horn ; but the apical horn of *G. ehrenbergii* is longer than the horn observed in *Cryptarchaeodinium*. *G. ehrenbergii* is twice the size of any described species of *Cryptarchaeodinium*.

With seven post-cingular plates, this new species is similar to *G. fetchamensis* and *G. palla* ; but it differs in details of tabulation, general aspect and size. The general structure and thick wall render this species similar to *G. scotti*, which was recorded from Lower Kimmeridgian of Australia by Cookson & Eisenack (1958) ; since Cookson and Eisenack were unable to determine the tabulation of *G. scotti*, of which they give a very incomplete description, and since the holotype was not available for study, the relationships between this latter species and *G. ehrenbergii* can not be commented on.

### ***Gonyaulacysta eisenacki*** (Deflandre) Sarjeant, 1969

(Pl. 3, fig. 9)

1938a *Gonyaulax eisenacki* Deflandre: 171–173, pl. 6, fig. 7 ; text-figs. 3–4.
1958 *G. eisenacki* Deflandre ; Cookson & Eisenack: 30, pl. 2, fig. 11.
1960 *G. eisenacki* Deflandre ; Klement: 29–30, pl. 2, figs. 9–10.
1962a *G. eisenacki* Deflandre ; Sarjeant: 258, pl. 1, fig. 4 ; tables 3, 4.
1962b *G. eisenacki* Deflandre ; Sarjeant, pl. 69, fig. 3 ; tables 2, 3.
1964 *G. eisenacki* Deflandre ; Downie & Sarjeant: 114.
1964 *G. eisenacki* Deflandre ; Eisenack: 355.
1964a *G. eisenacki* Deflandre ; Sarjeant, table 2.
1965 *G. eisenacki* Deflandre ; Górka: 299–300, pl. 1, figs. 5 a–c.
1965 *Gonyaulacysta eisenacki* (Deflandre) ; Sarjeant, *nomen nudum*, table 1.
1966 *G. eisenacki* (Deflandre) ; Sarjeant, *nomen nudum*: 131.
1967 *G. eisenacki* (Deflandre) ; Dodekova: 18–19, pl. 2, figs. 9–11.
1967b *Gonyaulax eisenacki* Deflandre ; Vozzhennikova: 81, pl. 21, figs. 1–3 ; pl. 22, figs. 1–6 ; pl. 23, figs. 1–6 ; pl. 24, figs. 1–8, tables 2, 11.
1967a *Gonyaulacysta eisenacki* (Deflandre) ; Sarjeant, table 1, *nomen. nudum.*
1968 *G. eisenacki* (Deflandre) ; Sarjeant: 227, pl. 3, fig. 4, table 2a.
1969 *G. eisenacki* (Deflandre) ; Sarjeant (in press).

Remarks. *G. eisenacki* has been recorded from the Middle Jurassic of East Prussia and Oxfordian of France by Deflandre (1938) ; from the Lower Oxfordian (Malm Alpha) of south-west Germany by Klement (1960), and from the Upper Jurassic of Moscow by Vozzhennikova (1967). In England it has previously been recorded from the Middle Callovian and Upper Oxfordian (Sarjeant, 1962, 1965). Recently Sarjeant observed it in the Upper Callovian and Lower Oxfordian of

Normandy (1968). This species characterized by the form of its high and denticulate crests and the character of apex and antapex, was observed in the Dorset assemblages.

FIGURED SPECIMEN. BM(NH) slide V.52800(1). Shaly clay from the *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : overall length 85 μ, breadth 50 μ ; shell length 55 μ, breadth 45 μ. Range of the specimens observed : overall length 83–98 μ, breadth 48–60 μ ; shell length 58–68 μ, breadth 45–50 μ.

Dimensions of the French specimens, according to Deflandre : overall length 65–80 μ, breadth 57–60 μ ; according to Sarjeant : overall length 70–80 μ, breadth 50–60 μ. Klement recorded dimensions of 78–98 μ length and 52–58 μ breadth. Dimensions of the Russian specimens, as given by Vozzhennikova : overall length 59·4–67·5 μ, breadth 57–64·7 μ. There is thus little difference in dimensions between the French, German, English and Russian specimens from the Upper Jurassic.

## *Gonyaulacysta* cf. *eisenacki* (Deflandre)

(Pl. 2, fig. 10)

REMARKS. The specimens, observed in the basal Kimmeridgian assemblages of Dorset and the Boulonnais, resemble *G. eisenacki* in their denticulate crests and general appearance, but differ in that the apex is rounded and there is no antapical pericoel. This form may be an extreme variant of *G. eisenacki* or may be a new species ; further and better specimens are required before this can be decided.

FIGURED SPECIMEN. BM(NH) slide V.52792(1). Shaly clay from the *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : overall length 59 μ, breadth 37 μ ; sutures 3–12 μ high. Other English specimens length 60–65 μ, breadth 50–55 μ. The French specimens were not measured because of their poor preservation.

## *Gonyaulacysta granulata* (Klement) Sarjeant, 1969

(Pl. 8, figs. 1, 2 ; Text-fig. 9)

1960 *Gonyaulax granulata* Klement: 39–41, pl. 4, figs. 10–13 ; text-figures 18–20.
1964 *G. granulata* Klement ; Downie & Sarjeant: 114.
1964 *G. granulata* Klement ; Eisenack: 357–358.
1964a *G. granulata* Klement ; Sarjeant, table 2.
1966 *G. granulata* Klement ; Schulz & Mai, table 1.
1966 *Gonyaulacysta granulata* (Klement) ; Sarjeant, *nomen nudum*: 131.
1967b *Gonyaulax granulata* (Klement) ; Vozzhennikova, table 11.
1967b *Gonyaulacysta granulata* (Klement) ; Sarjeant, *nomen nudum*, table 1.
1969 *G. granulata* (Klement) ; Sarjeant (in press).

DESCRIPTION. The broadly spherical shell is divided into two almost equal parts by the laevorotatory cingulum. A short apical horn is present. Tabulation : 4′, 6″, 6c, 6″′, 1p and 1″″. Moderately low sutures rise up on the plate boundaries.

Sulcus is short and broad. The precingular archaeopyle forms through loss of the plate 3″. Surface of the shell finely granular.

Figured specimen. BM(NH) slide V.53969(1). Clay from top of the Grès de Châtillon, south of Audresselles, Boulonnais (CC 450).

Dimensions. Figured specimen : overall length 62 μ, breadth 55 μ ; horn length 7 μ. Other French specimens (15 specimens measured) : overall length 62–80 μ, breadth 55–65 μ; horn length 6–7 μ. Range of the English specimens (2 specimens measured) : overall length 68–73 μ, breadth 70–72 μ ; horn length 6–8 μ. (Dimensions of the type material : length 66 μ, breadth 63 μ ; horn length 9 μ.)

Remarks. Klement has recorded *G. granulata* from the Upper Jurassic (Lower Oxfordian to Upper Kimmeridgian) of Germany. It is present in the Dorset and Boulonnais assemblages. The specimens from these localities correspond closely in general morphology to the German material, differing only in details of the shape of plates 1′, 3′ and 1″ ′.

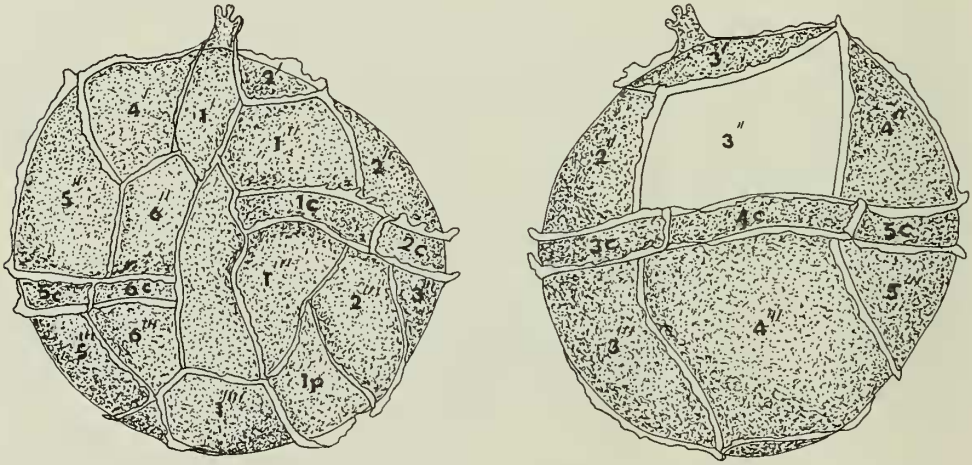

Fig. 9. *Gonyaulacysta granulata* (Klement). Tabulation. Left, ventral view ; right, dorsal view. Plate 3″ is missing to form the precingular archaeopyle. ×*c.* 1280.

## ***Gonyaulacysta granuligera*** (Klement) Sarjeant, 1969

(Pl. 1, figs. 10, 11 ; Text-fig. 10)

1960 *Gonyaulax granuligera* Klement: 41–42, pl. 5, figs. 4, 5.
1964 *G. granuligera* Klement ; Downie & Sarjeant: 114.
1964 *G. granuligera* Klement ; Eisenack: 359.
1964a *G. granuligera* Klement ; Sarjeant, table 2.
1966 *G. granuligera* Klement ; Schulz & Mai, table 1.
1966 *Gonyaulacysta granuligera* (Klement) ; Sarjeant, *nomen nudum*: 131.
1967b *Gonyaulax granuligera* Klement ; Vozzhennikova, table 11.
1967b *Gonyaulacysta granuligera* (Klement) ; Sarjeant, table 1, *nomen nudum.*
1969 *G. granuligera* (Klement) ; Sarjeant (in press).

Description. Shell subspherical to elongate, with a long apical horn. Tabulation : 4′, 6″, 6c, 6″′, 1″″. Cingulum narrow and laevorotatory, dividing the shell into two unequal parts : epitract longer than the hypotract. Plate boundaries spiny ; spines short, solid and distally acute or blunt. Precingular archaeopyle forms by loss of the plate 3″. Surface densely granular.

Figured specimen. BM(NH) slide V.53972(1). Clay from top of the Grès de Châtillon, south of Audresselles, Boulonnais (CC 450).

Dimensions. Figured specimen : overall length 73 $\mu$, breadth 65 $\mu$ ; horn length 8 $\mu$ ; length of the spines 1–3 $\mu$. Range of the English specimens (15 specimens measured) : overall length 65–73 $\mu$, breadth 50–75 $\mu$. French specimens (25 specimens measured) : overall length 68–72 $\mu$, breadth 60–65 $\mu$. German specimens :

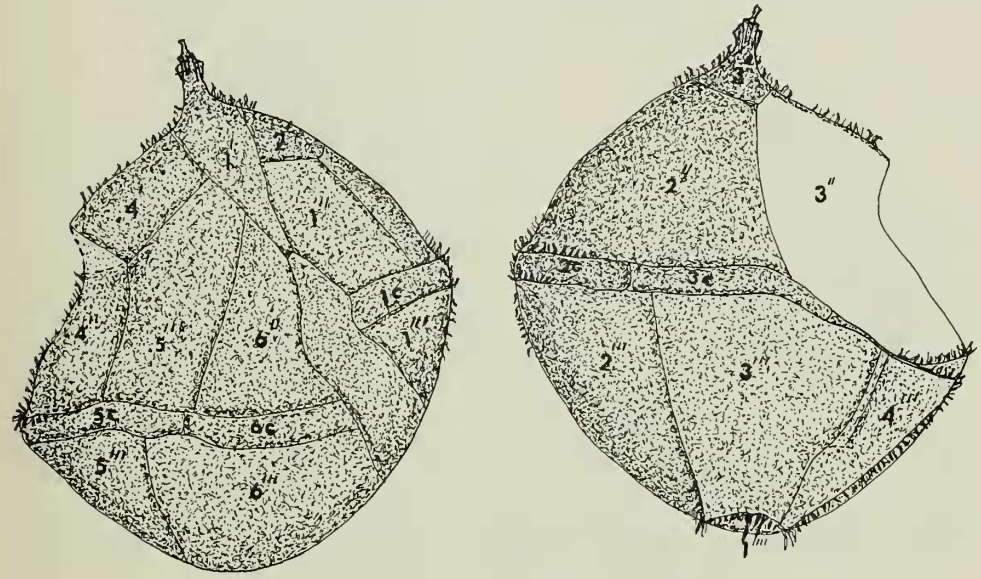


Fig. 10. *Gonyaulacysta granuligera* (Klement). Tabulation and the archaeopyle formation (plate 3″ is missing). Left, ventral view ; right, dorsal view. ×*c.* 1280.

length 72–84 $\mu$, breadth 58–69 $\mu$ ; horn length 9–12 $\mu$ (quoted by Klement). English and French specimens are thus more spherical and their horns shorter than the type species.

Remarks. *C. granuligera* has been recorded from Malm Upper Alpha to Lower Delta (Kimmeridgian) of Germany (Klement, 1960). The interpretation of the tabulation here made is slightly different from Klement's, as might be expected in view of the densely granular surface : plates 1p and 1ppl, mentioned by Klement, were not observed.

### *Gonyaulacysta* cf. *helicoidea* (Eisenack & Cookson)

(Pl. 2, figs. 1, 2; Text-fig. 11)

Description. An almost spherical theca with a short and broad, blunt apical horn. Tabulation : 4′, 1a, 6″, 6c, 6‴, 1p and 1‴″. Denticulate crests rise up from the plate boundaries ; the height and character of denticulation are variable. The strongly spiral cingulum separates the epitract and the hypotract, which are almost equal in size. Sulcus sigmoidal. Surface of the shell tuberculate ; scattering of the tubercules irregular. Precingular archaeopyle forms by loss of plate 3″.

Figured specimen. BM(NH) slide V.53931(1). Clay from the *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Figured specimen : overall length 45 $\mu$, breadth 40 $\mu$ ; horn length 5 $\mu$. Holotype dimensions (given by Eisenack and Cookson) are length 78 $\mu$, breadth

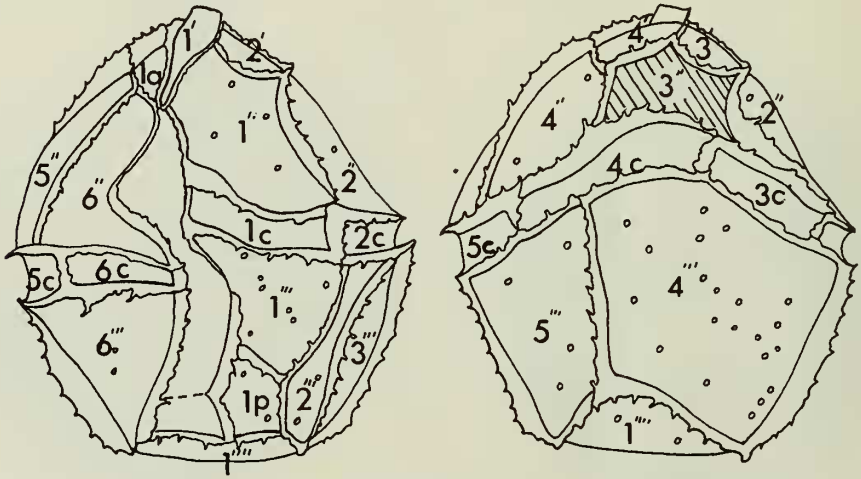


Fig. 11. *Gonyaulacysta* cf. *helicoidea* (Eisenack & Cookson). Tabulation. Left, ventral view ; right, dorsal view. ×*c.* 1360.

56 $\mu$. Range of English specimens (as quoted by Sarjeant) : overall length 44–53 $\mu$, breadth 42–46 $\mu$.

Remarks. *G. helicoidea* was originally recorded from the Lower Cretaceous (Aptian or older) of South Australia by Eisenack and Cookson (1960) ; subsequently Sarjeant observed it in the Speeton Clay of England (Lower Barremian), emended the diagnosis, and gave an exact tabulation of the species (1966). It was also observed in the Barremian of Russia by Vozzhennikova (1967).

A single, excellently preserved specimen was recorded from the basal Kimmeridgian of Normandy. This specimen is closely comparable with the specimen figured by Sarjeant ; the only difference is in the height of the apical horn (although it has been mentioned that the length of the horn is very variable, by Sarjeant, 1966c). Dimen-

sions of the Kimmeridgian specimen similar to the English (Barremian) specimens, but both are smaller than the Australian (Aptian) holotype.

The stratigraphic range of *G. helicoidea* is from Barremian to Aptian ; therefore this is an unexpected observation in the base of Kimmeridgian assemblages. Since this form is different from the typical *G. helicoidea*, it is considered preferable not to place this specimen in the latter species until a larger assemblage of specimens is available for study.

### *Gonyaulacysta hyaloderma* (Deflandre), emend.

(Pl. 9, figs. 9, 10 ; Text-fig. 12)

1939 *Plaeoperidinium hyalodermum* Deflandre: 144, pl. 6, figs. 3, 4.
1941 *P. hyalodermum* Deflandre ; Deflandre: 17, pl. 5, figs. 10–12.
1957 *P. hyalodermum* Deflandre ; Downie: 422, pl. 20, fig. 9.
1964 *P. hyalodermum* Deflandre ; Downie & Sarjeant: 137.
1964 *P. hyalodermum* Deflandre ; Eisenack: 603.
1964a *P. hyalodermum* Deflandre ; Sarjeant, table 2.
1965 *P. hyalodermum* Deflandre ; Coninck: 16, pl. 3, fig. 3.
1967a *Gonyaulacysta hyaloderma* (Deflandre) ; Sarjeant:252.
1967b *G. hyaloderma* (Deflandre) ; Sarjeant, table 1.

Emended diagnosis. A *Gonyaulacysta* with thin-walled, spherical to ovoidal shell terminating in a short, blunt horn. Tabulation : 4′, 6″, 6c, 6″ ′, 1p and 1″ ″. Plate boundaries demarcated by moderately high, delicate crests with smooth or denticulate edges. Epitract and hypotract are almost equal in size and separated by laevorotatory helicoidal cingulum. Sulcus broadening posteriorly, weakly sigmoidal. Surface of the shell smooth. Precingular archaeopyle forms by loss of plate 3″.

Holotype. Specimen AP 2, Deflandre coll., Ecole Pratique des Hautes Etudes, Paris, from Kimmeridgian of Orbagnoux, France.

Figured specimen. BM(NH) slide V.53932(1). Clay from the *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Holotype : length 42 μ, breadth 35 μ ; length of the apical horn 3 μ. Figured specimen : overall length 44 μ, breadth 40 μ ; horn length 4 μ. Dimensions of the specimen from Eocene of Belgium (as quoted by Coninck) : length 42 μ, breadth 32 μ ; horn length 7 μ. According to these measurements, the dimensions of the specimens from the Kimmeridgian and Eocene are similar.

Description. Shell broadly ovoidal, with a short and broad horn at the apex, and the hypotract rounded. The crests separating the four apical plates meet at the apex. Plate 1′ occupies the anterior prolongation of the sulcus ; it is long and broadening towards the apex. Plate 2′ is the largest of the apical plates and forms the apical horn together with plate 1′. Six precingular plates are present ; they are moderately large. Plate 6″ is elongate and narrower than the others. The six postcingular plates are of variable size. Plate 1″ ′ is the smallest, triangular in shape ; plate 3″ ′ and 4″ ′ are larger, quadrate and occupy the whole dorsal side of the hypo-

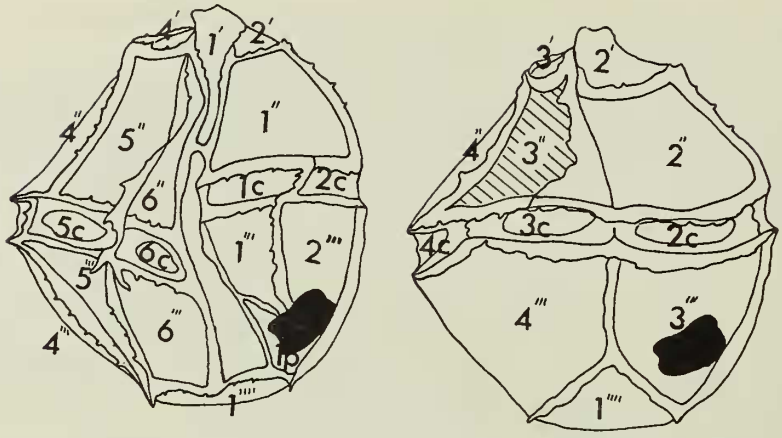


FIG. 12. *Gonyaulacysta hyaloderma* (Deflandre). Tabulation and the archaeopyle formation (plate 3″ is missing). Left, ventral view ; right, dorsal view. ×*c.* 1300.

tract ; 6″ ′ is square in shape. A posterior intercalary plate (1p) separates plate 1″ ′ from the single, polygonal antapical plate (1″ ″). The shell wall and crests are delicate.

REMARKS. The diagnosis is emended to include reference to the tabulation. which was not determined by Deflandre. Downie attempted to reconstruct the tabulation on the basis of a single poorly preserved specimen ; however, he was doubtful about his reconstruction and prefaced most plate labels with a question mark. The reconstruction is here made on the basis of a single, excellently preserved specimen from the *Liostrea delta* Bed of Normandy. The species was not encountered in the English and Scottish assemblages.

*G. hyaloderma* was originally recorded from the Kimmeridgian of France (Deflandre, 1939b) ; subsequently, Downie observed it in the Kimmeridge Clay of Dorset and Coninck observed in the Eocene of Belgium. The specimens figured by Downie and Coninck both have longer apical horn than the holotype.

The systematic placing of this species was discussed by Sarjeant (1967) after he was able to examine the holotype, and it was redesignated as *Gonyaulacysta hyaloderma.*

### ***Gonyaulacysta jurassica*** var. ***longicornis*** Deflandre, 1938

(Pl. 5, fig. 11)

1938a *Gonyaulax jurassica* var. *longicornis* Deflandre: 171, pl. 6, fig. 6.
1958 Peridinian Lantz, pl. 7, fig. 74.
1960 *G. jurassica* var. *longicornis* Deflandre ; Klement, pl. 2, figs. 6–8.
1961a *G. jurassica* var. *longicornis* Deflandre ; Sarjeant: 92–94 ; text-figs. 2, 3, 15.
1962a *G. jurassica* var. *longicornis* Deflandre ; Sarjeant: 258, pl. 1, fig. 3.
1964 *G. jurassica* var. *longicornis* Deflandre ; Downie & Sarjeant: 115.
1964 *G. jurassica* var. *longicornis* Deflandre ; Sarjeant, table 2.

1964 *Gonyaulacysta jurassica* var. *longicornis* (Deflandre) ; Deflandre: 5.
1967b *Gonyaulax jurassica* var. *longicornis* Deflandre ; Vozzhennikova: 85, pl. 19, fig. 5 ; tables 2, 11.

Remarks. This variety of *G. jurassica* has been recorded from the Upper Jurassic of France, Germany, England and Russia. It was observed in the samples from the basal Kimmeridgian of Dorset, Le Havre and the Boulonnais.

Figured specimen. BM(NH) slide V.53939(1). Clay from Exogyra Marls, *c.* 1 m. above the Upper Hard Band, Cap de La Hève, Le Havre (CH 185).

Dimensions. Figured specimen : overall length 75 $\mu$, breadth 45 $\mu$ ; horn length 21 $\mu$. Range : overall length 75–145 $\mu$, breadth 40–80 $\mu$ ; horn length 18–25 $\mu$. (Holotype dimensions : length 88 $\mu$, breadth 54 $\mu$ ; horn length 30 $\mu$, as quoted by Deflandre.) 6 specimens measured.

## ***Gonyaulacysta*** cf. ***mamillifera*** (Deflandre)

(Pl. 3, fig. 4)

Description. Relatively large shell, ovoidal in shape. The nearly circular cingulum divides the shell into two equal parts : epitract terminates in a mamelon form, that is broader than one is usual for an apical horn, and hypotract rounded. The plate boundaries are marked by low membraneous crests. Surface of the shell densely granular ; as a result tabulation not clear. On the dorsal side, a precingular archaeopyle is present, and possibly formed by loss of plate 3″.

Figured specimen. BM(NH) slide V.53965(1). Clay from Argiles de Moulin Wibert, 20 ft. below the top, south side of Cap de la Crèche, Boulonnais (CC 447).

Dimensions. Figured specimen : length 88 $\mu$, breadth 60 $\mu$. Holotype (as measured by Deflandre) ; length 92 $\mu$, breadth 84 $\mu$.

Remarks. *G. mamillifera* has only been recorded from the Kimmeridgian of France (Deflandre, 1939). A single specimen was observed in the basal Kimmeridgian assemblage from the Boulonnais. It is very similar to the holotype, but is narrower in size and is without the spinose sutures. Allocation to this species is therefore provisional only.

## ***Gonyaulacysta nuciformis*** (Deflandre) Sarjeant, 1969

(Pl. 6, fig. 1)

1938a *Palaeoperidinium nuciforme* Deflandre: 180, pl. 8, figs. 4–6.
1962a *P. nuciforme* Deflandre ; Sarjeant, pl. 1, fig. 8, tables 3, 4.
1962b *Gonyaulax nuciformis* (Deflandre) ; Sarjeant: 482–483, pl. 69, fig. 6 ; text-fig. 4; tables 2–3.
1964 *G. nuciformis* (Deflandre) ; Downie & Sarjeant: 115.
1964 *Palaeoperidinium nuciforme* Deflandre ; Eisenack: 609.
1964a *Gonyaulax nuciformis* (Deflandre) ; Sarjeant, table 2.
1965 *Palaeoperidinium nuciformoides* Gorka: 300–301, pl. 2, figs. 1–2.
1966 *? Gonyaulacysta nuciformis* (Deflandre) ; Sarjeant, *nomen nudum*: 132.

1967b *Gonyaulax nuciformis* (Deflandre) ; Vozzhennikova, table 11.
1967b *? Gonyaulacysta nuciformis* Deflandre ; Sarjeant, table 1, *nom. nud.*
1968 *G. nuciformis* (Deflandre) ; Sarjeant: 227, pl. 3, fig. 4.
1969 *? G. nuciformis* (Deflandre) ; Sarjeant (in press).

*Gonyaulacysta nuciformis* was first recorded from the Upper Jurassic of France by Deflandre (1938) ; he was uncertain as to its tabulation and placed it in the " waiting genus " *Palaeoperidinium.* Later Sarjeant observed it in the assemblages from Upper Callovian to Oxfordian of England and France (1962, 1964) ; on the basis of observation of its tabulation, he placed it in the genus *Gonyaulax* and has since transferred it to the cyst-genus *Gonyaulacysta.*

The geographic range of this species is extended to Poland by the observation in the Upper Jurassic assemblage of Magnuszew, Poland (Górka, 1965). The Polish specimens were described as a new species, but Sarjeant (1968) considers that this should be treated as a subjective junior synonym, since the diagnostic character (difficulty in observing tabulation) is thought to be inadequate.

It is present in moderate abundance in the assemblages from the basal Kimmeridgian of England, France and Scotland. The specimen of this type comparable with the specimen figured by Sarjeant (1962) ; having a spherical to ovoidal shape with thick-walled and densely granular surface are similar. Determination of the tabulation is difficult because of the wall structure of this species. A precingular archaeopyle is present, possibly formed by loss of plate 3″.

Figured specimen. BM(NH) slide V.52793(2). Shaly clay from the *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

Dimensions. Figured specimen : overall length 50 μ, breadth 43 μ ; horn length 7 μ. Range of English specimens (17 specimens measured) overall length 50–100 μ, breadth 40–85 μ ; horn length 4–16 μ. Range of French specimens (5 specimens measured) : overall length 49–60 μ, breadth 45–70 μ ; horn length 4–7 μ. Range of Scottish specimens (2 specimens measured) : overall length 70–80 μ, breadth 65–66 μ ; horn length 5–7 μ.

The following dimensions are quoted by Deflandre : overall length 60–65 μ, breadth 47–53 μ (approximately). Dimensions of the Callovian specimens (as quoted by Sarjeant) : overall length 56–58 μ, breadth 50–64 μ. Polish specimens ; overall length 38–54 μ, breadth 40–44 μ (as given by Górka).

### *Gonyaulacysta serrata* (Cookson & Eisenack) Sarjeant, 1969a

(Pl. 5, fig. 7)

1958 *Gonyaulax serrata* Cookson & Eisenack: 34, pl. 3, fig. 2 ; text-figs. 12–14.
1960a *G. serrata* Cookson & Eisenack ; Cookson & Eisenack: 244.
1964 *G. serrata* Cookson & Eisenack ; Downie & Sarjeant, 115.
1964 *G. serrata* Cookson & Eisenack ; Eisenack: 403–404.
1964a *G. serrata* Cookson & Eisenack ; Sarjeant, table 2.
1966 *Gonyaulacysta serrata* (Cookson & Eisenack) ; Sarjeant, *nomen nudum*: 131.
1967b *Gonyaulax serrata* Cookson & Eisenack ; Vozzhennikova, table 11.
1967b *Gonyaulacysta serrata* (Cookson & Eisenack) ; Sarjeant, table 2, *nom. nud.*
1969 *G. serrata* (Cookson & Eisenack) ; Sarjeant (in press).

This species has been recorded from the Tithonian to Neocomian of Australia and New Guinea by Cookson and Eisenack. Badly preserved specimens, apparently attributable to it, were observed in the samples studied from Dorset, Scotland, Normandy and the Boulonnais.

These specimens agree with the diagnosis of the holotype in their general appearance and the character of the sutures. Holotype tabulation was not determined by Cookson and Eisenack ; the specimens from the basal Kimmeridgian likewise do not present a determinable tabulation.

Figured specimen. BM(NH) slide V.53935(1). Clay from the *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Figured specimen : overall length 75 $\mu$, breadth 70 $\mu$. Range of English specimens (5 specimens measured) : overall length 80–109 $\mu$, breadth 70–106 $\mu$ ; French specimens (7 specimens measured) : overall length 75–100 $\mu$, breadth 70–100 $\mu$ ; Scottish specimen overall length 45 $\mu$, breadth 50 $\mu$. The range of Australian specimens (as given by Cookson and Eisenack) length 100–109 $\mu$, breadth 94–100 $\mu$.

## *Gonyaulacysta* sp. A

(Pl. 3, fig. 3, Text-fig. 13)

Description. A thick-walled ovate cyst with an apical horn formed by three apical plates. Reflected tabulation : 3′, 1a, 6″, 6c, 6″′, 1p, 1pv and 1″″. Plate boundaries marked by low crests with poorly defined rows of low spines.

Plate 1′ is elongate, extending to the anterior end of the sulcus ; plates 2′ and 3′ are located above the plates 2″, 3″ and 4″. The single anterior intercalary plate (1a) is large and angular in shape. Precingular plates 1″, 2″, 3″ and 4″ are more or less of the same size ; 5″ is the largest of the precingular plates ; plate 6″ is smaller because of the presence of plate 1a. The cingulum is slightly laevorotatory and nearly equatorial, formed by six cingular plates, plate 1c being very small.

Postcingular plates 1″′ and 2″′ are pentagonal in shape ; 1″′ is the smallest of the postcingular plates. Plate 3″′, 4″′ and 5″′ are large, 6″′ is small and triangular-shaped. The posterior intercalary plate 1p is small and elongate. Plate 1pv separates the sulcus from the large, convex antapical plate 1″″.

The surface of the plates is densely granular and sparsely spiny ; these spines are higher than the sutural spines.

Precingular archaeopyle is present and forms by loss of plate 3″ ; on the figured specimen since the plate 3″ remains attached, the archaeopyle appears as a split.

Figured specimen. BM(NH) slide V.53930(1). Clay from the *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Figured specimen : overall length 65 $\mu$, breadth 42 $\mu$ ; horn length 5 $\mu$ ; length of the spines on the crests 1–2 $\mu$, length of the surface spines 4 $\mu$. The second specimen could not be measured, because of its bad preservation.

Remarks. Two specimens were observed ; the figured specimen is well preserved, but the second is not. From its general appearance and tabulation this may be an

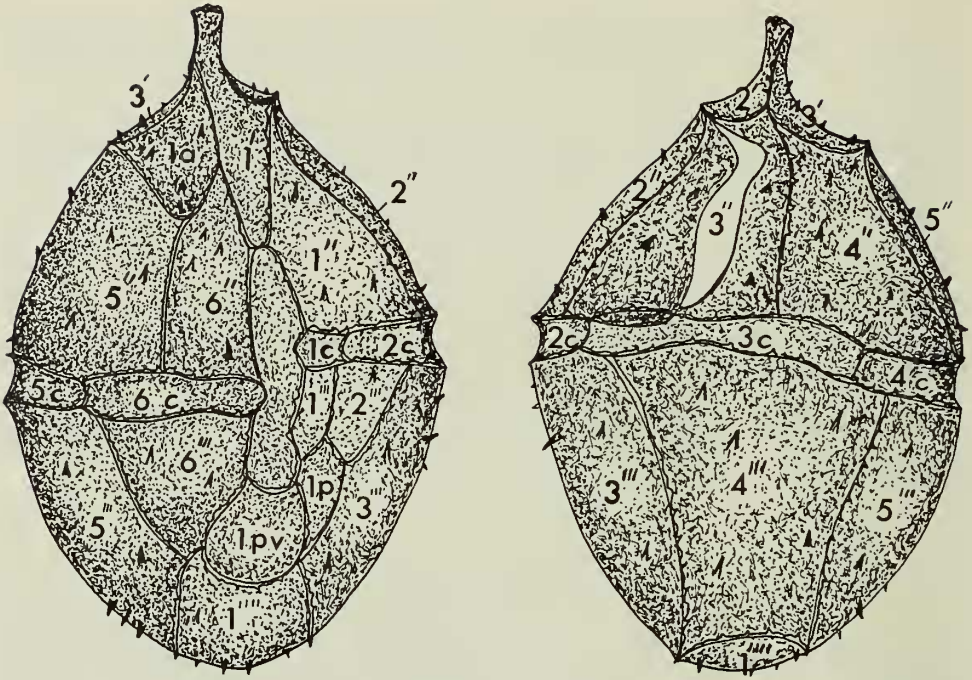


FIG. 13. *Gonyaulacysta* sp. A. Tabulation and the archaeopyle formation (plate 3″ remains attached). Left, ventral view ; right, dorsal view. ×*c.* 1280.

undescribed species of *Gonyaulacysta*. These two specimens differ from all previously described species in their tabulation and spiny surface.

### *Gonyaulacysta* sp. B

(Pl. 6, fig. 3 ; Text-fig. 14)

DESCRIPTION. The broadly ovoidal theca terminates in a poorly developed apical horn. Tabulation: 4′, 1a, 6″, 6c, 6‴, 1p, 1pv and 1⁗. Spiny crests of moderate height rise up on the plate boundaries. A slightly helicoid, laevorotatory cingulum of moderate breadth divides the theca into two unequal parts: the epitract is larger than the hypotract, almost $\frac{2}{3}$ of the shell length. The hypotract is dome-shaped. The sulcus is moderately broad, extending on both epitract and hypotract to the same length. The surface of the shell is densely granular.

Apical plate 1′ is elongate, its anterior and posterior ends being narrow ; together with plate 3′, it forms the apical horn. Plate 2′ is quite large ; 4′ is the smallest of the apical plates. The single anterior intercalary plate 1a is large ; as a result plate 6″ is reduced. Plate 1″ is long and narrow ; plates 2″, 3″, 4″ and 5″ are large.

Plate 1‴ is quadrate, as small as the single sulcal plate. All the other postcingular plates are relatively large. Posterior intercalary plate 1p is small and triangular,

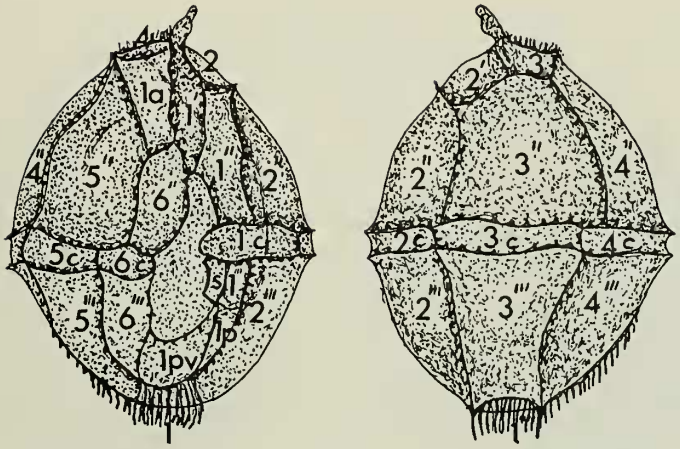


FIG. 14. *Gonyaulacysta* sp. B. Tabulation. Left, ventral view ; right, dorsal view. ×*c.* 950.

placed below plate 1″ ′. A crescent-shaped plate (1pv) separates the single antapical plate 1″ ″ from the sulcus. Plate 1″ ″ is characteristically surrounded by long (nearly three times longer than the sutural spines), thin, simple spines. No archaeopyle was seen.

FIGURED SPECIMEN. BM(NH) slide V.53965(2). Clay from Argiles de Moulin Wibert (20 ft. below the top) south side of Cap de La Crèche, Boulonnais (CC 447).

DIMENSIONS. Figured specimen : overall length 78 $\mu$, breadth 50 $\mu$ ; horn length 8 $\mu$ ; length of the sutural processes 3–5 $\mu$, antapical processes 8 $\mu$ ; breadth of the cingulum 3–5 $\mu$. The second specimen could not be measured.

REMARKS. Only two specimens were encountered, one of them badly preserved but the other good enough for study. With their long processes around the antapex, these specimens are different from all described species of *Gonyaulacysta* ; this is probably a new species but, for fuller knowledge, more specimens must be examined.

### *Gonyaulacysta* sp. C

(Pl. 4, figs. 10, 11 ; Text-fig. 15)

DESCRIPTION. This is an infrequent species. All the three specimens encountered are somewhat crushed, folded or covered by debris ; the one figured was the best oriented for study. The surface is densely granular ; because of the granulation and bad orientation, it was difficult to distinguish the tabulation.

The thick-walled theca is almost spherical, with a moderately long apical horn. Tabulation : 4′, 1a, 6″, 6–7c, 7″ ′, 1p, 1pv, 1″ ″. Plate 1′ occupies the anterior prolongation of the sulcus. Plates 2′ and 3′ are small ; the position of the boundary between them was not confirmed. Plate 4′ is almost as large as plate 1′. The single anterior intercalary plate is small, placed between the plates 4′ and 6″. The pre-

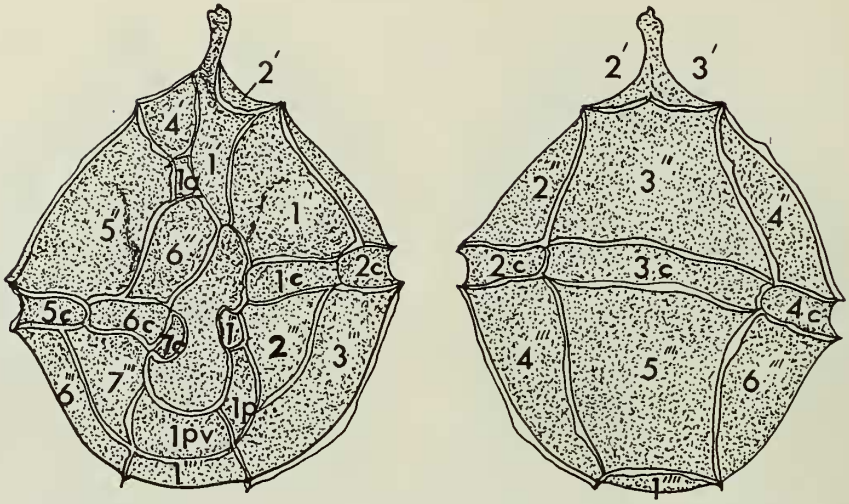


Fig. 15. *Gonyaulacysta* sp. C. Tabulation. Left, ventral view ; right, dorsal view. ×*c.* 800.

cingular plates are generally large, plate 6″ being of reduced size because of the intercalary plate 1a.

The postcingular plates are of variable size and shape : plates 1″′ and 1p are both small, plate 2″′ is also reduced and does not have a boundary with the antapical plate. Plates 3″′, 4″′, 5″′ and 6″′ are relatively large ; plate 7″′ is in contrast reduced, having nearly the same size as plate 2″′. The quite broad posterior intercalary plate 1pv separates the sulcus from the single antapical plate 1″″.

The plate boundaries are demarcated by delicate crests of variable height.

The cingulum is of moderate breadth, helicoid and laevorotatory. The number of the cingular plates is hesitantly mentioned because the character of the small plate beside 6c is doubtful ; it may be either a cingular plate or a sulcal plate. The sulcus is short, broadening posteriorly.

A precingular archaeopyle, formed by loss of plate 3″, was seen in one of the three specimens.

Figured specimen. BM(NH) slide V.53966(1). Clay from Argiles de Moulin Wibert, 20 ft. below the top, on the south side of Cap de La Crèche, Boulonnais (CC 447).

Dimensions. Figured specimen : overall length 68 μ, breadth 62 μ ; horn length 8 μ ; height of the crests 4–5 μ. Range : overall length 65–68 μ, breadth 58–62 μ ; horn length 8–12 μ.

Remarks. In its general form, this unnamed species of *Gonyaulacysta* differs from all described species. The most closely similar species is *G. palla*, which has similarly spherical shape and comparable tabulation ; but this form differs from it in its apical horn, sutural crests, absence of plate 1a, and presence of plate 1pv.

Because of its seventh postcingular plate it is comparable with *G. fetchamensis* and *G. ehrenbergii*, but its other morphologic features are different. The naming of this species is deferred until further, better specimens are available.

## Genus *OCCISUCYSTA* gen. nov.

Derivation of the name. Latin, *occisus*, ruined, lost, undone ; with reference to loss of two precingular plates in archaeopyle formation. Greek, *kystis*, cell, cyst.

Diagnosis. Proximate dinoflagellate cysts, spherical, subspherical or broadly ovoidal, with the tabulation 4′, 0–1a, 6″, 6c, 6–7‴, 1p, 0–1pv, 1⁗. Cingulum strongly or weakly helicoid ; sulcus generally extending onto epitract. Strong apical horn present, median and antapical horns lacking. Sutures in form of high ridges, denticulate, fenestrate or spiny. Surface of the shell is granular or tuberculate. Precingular archaeopyle is normally present and forms by loss of two precingular plates (2″ and 3″).

Type species. *Occisucysta balios* sp. nov. Base of the Kimmeridgian (Upper Jurassic), Normandy.

Remarks. This genus is similar to *Gonyaulacysta* in its tabulation, but distinguished by the loss of two precingular plates in archaeopyle formation.

Two new species from the Kimmeridgian assemblages studied, accord with the diagnosis of this genus; a third species is transferred from the genus *Gonyaulacysta*, since it has a two-plate precingular archaeopyle.

### *Occisucysta balios* sp. nov.

(Pl. 5, figs. 1, 2 ; Text-fig. 16)

Derivation of the name. Greek, *balios* spotted, with reference to the tubercules on the surface.

Diagnosis. *Occisucysta* having a subspherical shell terminating in a strong, thick apical horn. Antapex rounded, dome-shaped. Tabulation : 4′, 1a, 6″, 6c, 7‴, 1p, 1pv, 1⁗. The crests on the sutures are denticulate and fenestrate. Cingulum strongly helicoid, laevorotatory. Sulcus mainly confined to the epitract. Surface of the shell granular and sparsely tuberculate.

Holotype. BM(NH) slide V.53934(2). Kimmeridge Clay from the *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Holotype : overall length 60 μ, breadth 60 μ ; shell length 50 μ, breadth 55μ ; horn length 8 μ, breadth 6 μ. Dimensions of French specimens (4 specimens measured) : length 58–62 μ, breadth 58–59 μ ; horn length 5–8 μ, breadth 5–7 μ. Tubercules approximately 0·5–1·2 μ in diameter. English specimen overall length 55 μ, breadth 63 μ ; horn length 10 μ.

Description. This proximate cyst has an apical horn which is formed by all four apical plates. Plate 1′ is elongate, narrowing as it approaches the horn ; the

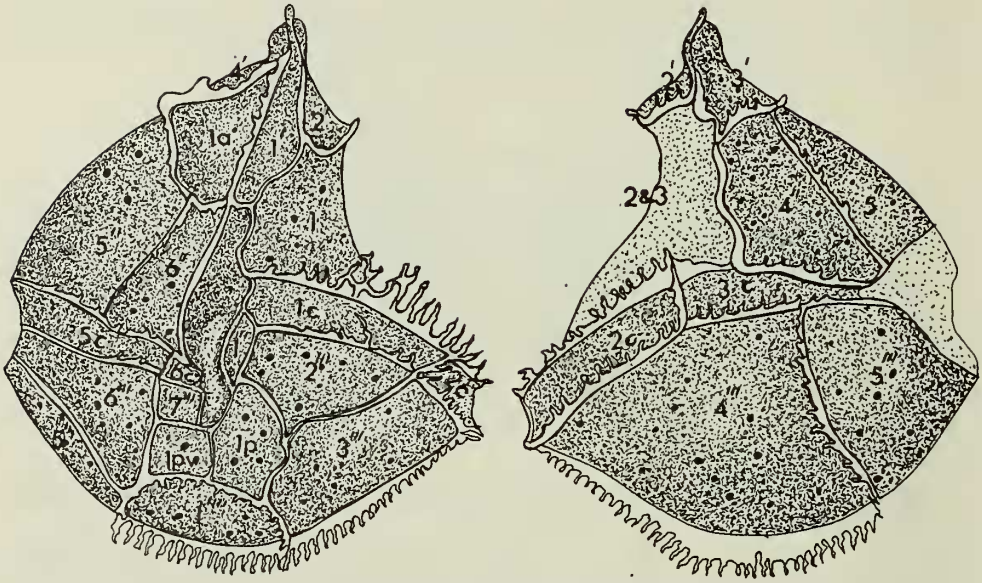


FIG. 16. *Occisucysta balios* sp. nov. Tabulation and the archaeopyle formation of the holotype (plates 2″ and 3″ are missing). Left, ventral view ; right, dorsal view. ×*c.* 1280.

other apical plates are relatively large, roughly triangular. Intercalary plate 1a is large, and the precingular plate 6″ is reduced. Plate 5″ is longer than the other surviving precingular plates. Identification of cingular plates was rendered problematical because of the poor preservation and the high crests, which partially obscure the shell itself.

Six postcingular plates are present. Plate 1‴ is very small. Plate 4‴ is largest and 7‴ is smallest of the plates ; because of its unusual situation, above the posterior intercalary plate 1pv, plate 7‴ could alternatively be regarded as sulcal plate. Posterior intercalary plate 1p is quite large, 1pv is tetragonal in shape. A single plate occupies the antapex, 1″″.

Surface of the plates granular with, in addition to, an irregular scatter of tubercles. The number of the tubercles on each plate is between 1 and 16 ; no tubercles were observed on the cingulum and sulcus. The membraneous crests on the sutures distally deeply denticulate or fenestrate.

REMARKS. The specimens observed were broken and badly preserved, the holotype being the best preserved. (It is probable that the large archaeopyle may help to render this species especially susceptible to further damage.) It is similar to the species of *Gonyaulacysta* in its tabulation, but it is easily distinguished from all previously described species by its tuberculate surface and the archaeopyle formation by loss of two precingular plates.

### *Occisucysta* sp.

(Pl. 7, fig. 8)

Description. This proximate cyst is spherical in shape, with a long apical horn and flattened antapex. The cingulum divides the theca into two parts, with the epitract slightly smaller than the hypotract. Because of the poor preservation, the tabulation was not fully determinable, but it appears to be typical for the genus. The plates on the dorsal side only were determinable : 3 apical, 4 precingular, 3 cingular, 4 postcingular and 1 antapical plates were observed. Two precingular plates, probably 2″ and 3″, are lost to form the large archaeopyle which is characteristic for the genus. The plate boundaries bear complex spines ; also there are some spines at the tip of the horn. The surface of the shell is densely granular.

Figured specimen. BM(NH) slide V.53945(1). Clay from the immediate base of the Kimmeridge Clay, Ringstead Bay, Dorset (RB 219).

Dimensions. Figured specimen : overall length 78 $\mu$, breadth 77$\mu$ ; horn length 25 $\mu$, sutures 5–7 $\mu$ high.

Remarks. Only a single poorly preserved specimen was available for study : it was attributed to the genus *Occisucysta*, since it has a large archaeopyle formed by loss of two plates. It differs from *O. balios*, in its long apical horn, details of the plates, and form of the crests. This new form is similar to *G. cladophora* in suture ornament and proportions, but it differs in the mode of archaeopyle formation. Better specimens are needed to determine fully the tabulation ; however, it is attributed to the genus *Occisucysta* without hesitation.

### ***Occisucysta evitti*** (Dodekova) comb. nov.

1969 *Gonyaulacysta evitti* Dodekova, 14–15, pl. 1, figs. 1–8; table 1

Remarks. This species, recently described from the Tithonian of Bulgaria, is characterised by a two-plate precingular archaeopyle. Although Dodekova did not mention the anterior intercalary plate 1a, the photographs of the holotype specimen of *G. evitti* show that the plate above plate 6″, which was indicated as plate 4′, is in fact the intercalary plate 1a, and that a boundary is present.

## Genus ***LEPTODINIUM*** Klement, emend. Sarjeant, 1969

### ***Leptodinium amabilis*** (Deflandre) Sarjeant, 1969

Plate 12, figs. 1, 2

1939 *Gonyaulax amabilis* Deflandre: 141–145, pl. 6, fig. 8.
1941 *G. amabilis* Deflandre ; Deflandre: 11, pl. 3, figs. 8, 9 ; text-figs. 1, 2.
1964 *G. amabilis* Deflandre ; Downie & Sarjeant: 113.
1964 *G. amabilis* Deflandre ; Eisenack: 315–316.
1964a *G. amabilis* Deflandre ; Sarjeant, table 2.
1966 *Gonyaulacysta amabilis* (Deflandre) ; Sarjeant, *nomen nudum*: 130.

1967b *Gonyaulax amabilis* Deflandre ; Vozzhennikova, 91 table 11.
1967a *Gonyaulacysta amabilis* (Deflandre) ; Sarjeant, *nomen nudum*, table 1.
1969 *Leptodinium amabilis* (Deflandre) ; Sarjeant (in press).

Remarks. *Leptodinium amabilis* has been recorded from the Kimmeridgian of France by Deflandre (1939, 1941). It was observed also in the assemblages from England and France. Their general structure and the number of the plates correspond closely to Deflandre's holotype, but the preservation of the basal Kimmeridgian specimens was not good enough for fuller study.

Figured specimen. BM(NH) slide V.52805(1). Clay from 15 ft. above Ringstead Coral Bed. West of Osmington Mills, Dorset (OM 419).

Dimensions. Figured specimen : length 43 $\mu$, breadth 35 $\mu$ ; second English specimen length 40 $\mu$, breadth 36 $\mu$. Length of French specimen 50 $\mu$, breadth 45 $\mu$. These specimens are larger than the holotype (as quoted by Deflandre) length 38 $\mu$, breadth 32 $\mu$.

### *Leptodinium arcuatum* (Klement), emend.

(Pl. 7, figs. 1, 2 ; Text-fig. 17)

1960 *Leptodinium arcuatum* Klement: 48, pl. 6, figs. 5, 6.
1964 *L. arcuatum* Klement ; Downie & Sarjeant: 126.
1964 *L. arcuatum* Klement ; Eisenack: 489.
1964a *L. arcuatum* Klement ; Sarjeant, table 2.
1966 *L. arcuatum* Klement ; Sarjeant, *nomen nudum*: 135.
1967a *L. arcuatum* Klement ; Sarjeant, *nomen nudum*, table 2.
1969 *L. arcuatum* Klement ; Sarjeant (in press).

Emended diagnosis. A *Leptodinium* having a relatively large, subspherical shell. Tabulation : 4′, 1a, 6″, 6c, 5″ ′, 1p and 1″ ″ ; plates bordered by delicate, high crests. Cingulum helicoid, laevorotatory ; sulcus long, extending on the epitract and hypotract for nearly equal lengths and broadening on the hypotract. Surface of the shell very finely granular or smooth. A large precingular archaeopyle forms by loss of plate 3″.

Holotype. Specimen Pr. 1149/67, Tübingen, Geol.-Paläont. Institut ; from Malm Upper Alpha (Oxfordian), borehole core between 1783·1 and 1785·9 m. depth. South Germany.

Figured specimen. BM(NH) slide V.52799(1). Shaly clay from the base of Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

Dimensions. Holotype : overall length 74 $\mu$, breadth 77 $\mu$. Figured specimen : overall length 80 $\mu$, breadth 78 $\mu$ ; shell length 74 $\mu$, breadth 70 $\mu$. Range of the English specimens (5 specimens measured) : overall length 65–73 $\mu$, breadth 60–80 $\mu$ ; French specimens (3 specimens measured) : overall length 65–73 $\mu$, breadth 50–55 $\mu$.

Description. The subspherical shell is divided by the laevorotatory cingulum into two parts. The epitract is approximately hemispherical, the hypotract is in the form of a truncated cone. The crests are thin and high ; their distal edge is always smooth.

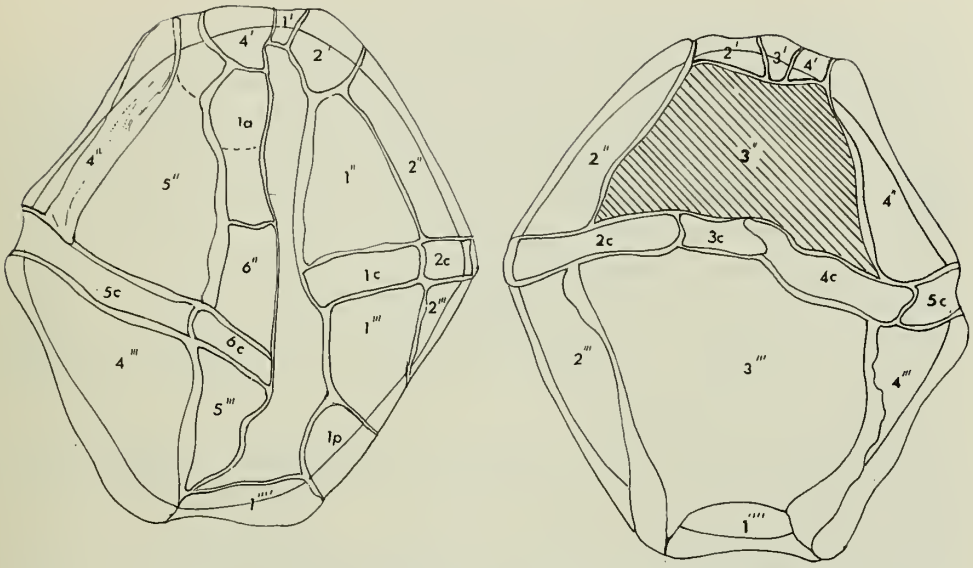


FIG. 17. *Leptodinium arcuatum* (Klement). Tabulation and the archaeopyle formation (plate 3″ is missing). Left, ventral view ; right, dorsal view. ×*c.* 1280.

The crests separate the four apical plates at the apex : plate 1′ and 3′ are smaller than plates 2′ and 4′. Precingular plates are large, only plate 6″ is somewhat reduced to accommodate intercalary plate 1a, which is long.

Five well-developed postcingular plates are present, plate 5‴ being smaller than the other postcingular plates. Posterior intercalary plate 1p is placed between the plates 1‴ and 1⁗. The antapex is occupied by a single antapical plate 1⁗.

The sulcus is long, extending between the apex and the antapex and broadening posteriorly.

REMARKS. The diagnosis is emended to include reference to the tabulation and the mode of archaeopyle formation, which were not mentioned by Klement.

*L. arcuatum* was originally recorded from the Oxfordian of Germany by Klement (1960). Well-preserved specimens were observed infrequently in both English (Dorset) and French (Normandy and the Boulonnais) assemblages.

### ***Leptodinium clathratum*** (Cookson & Eisenack) Sarjeant, 1969

(Pl. 11, fig. 8)

1960a *Gonyaulax clathrata* Cookson & Eisenack: 246–247, pl. 37, fig. 5 ; text-fig. 2.
1964 *G. clathrata* Cookson & Eisenack ; Downie & Sarjeant: 114.
1964 *G. clathrata* Cookson & Eisenack ; Eisenack: 339.
1964a *G. clathrata* Cookson & Eisenack ; Sarjeant, table 2.
1966 *Gonyaulacysta clathrata* (Cookson & Eisenack) ; Sarjeant, *nomen nudum*: 130.
1967b *G. clathrata* (Cookson & Eisenack) ; Vozzhennikova, table 11.

1967a *G. clathrata* (Cookson & Eisenack) ; Sarjeant, table 1, *nomen nudum*
1969 *Leptodinium clathratum* (Cookson & Eisenack) ; Sarjeant (in press).

Description. The relatively large shell is divided into two equal parts by the cingulum. Apical tabulation is not clear in this material ; tabulation : ?′, ?Oa, 6″, 6″ ′, 1p and 1″ ″. The precingular archaeopyle is present on the dorsal side, possibly formed by loss of plate 3″. Cingulum and sulcus are narrow, the cingulum being almost planar. Processes and apical horn lacking. The plate boundaries bear moderately high, delicate, membraneous crests.

Figured specimen. BM(NH) slide V.53971(1). Clay from top of the Grès de Châtillon, south side of Audresselles, Boulonnais (CC 450).

Dimensions. Figured specimen : overall length 105 μ, breadth 105 μ, crests 8–10 μ high. Diameters of the holotype (100×100 μ), as quoted by Cookson and Eisenack, are similar to these.

Remarks. *L. clathratum* has been previously recorded from the Upper Jurassic (probably Tithonian) of Australia and New Guinea (Cookson & Eisenack, 1960). This is the first time it has been observed in Europe. Unfortunately only one poorly preserved specimen was encountered.

This species is transferred to the genus *Leptodinium* by Sarjeant (1969, in press), since it has no apical horn.

### *Leptodinium egemenii* sp. nov.

(Pl. 10, figs. 5, 6 ; Text-fig. 18)

Derivation of the name. Named in honor of Dr. Recep Egemen, of the Geology Department of Ege University, Izmir, Turkey.

Diagnosis. *Leptodinium* with proximate cyst polygonal in outline ; with the reflected tabulation 4′, 6″, 6c, 6″ ′, 2p and 1″ ″. Processes and apical horn lacking. Cingulum slightly spiral, sulcus approximately spindle-shaped. Endophragm and periphragm are in contact except at the apex and antapex : a pronounced antapical pericoel is present, but the degree of separation at the apex is small. Surface of the shell smooth. Precingular archaeopyle formed by loss of plate 3″.

Holotype. BM(NH) slide V. 52794(1). Shaly clay from the *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

Dimensions. Holotype : overall length 70 μ, breadth 58 μ, shell length 54 μ, breadth 58 μ. Range of the English specimens (10 specimens measured) : length 50 (42)-80 (57) μ, breadth 40–50 μ ; French specimens (10 specimens measured) : length 55 (35)–78 (50) μ, breadth 43–52 μ ; Scottish specimen : length 65 (45) μ, breadth 48 μ (1 specimen measured). [The length of the endoblast is shown in parenthesis.]

Description. The thin-walled polygonal theca is divided into an approximately hemispherical epitract and a hypotract in the form of a truncated cone, the antapex being quite flat.

The first apical plate (1′) is elongate, situated in the anterior prolongation of the

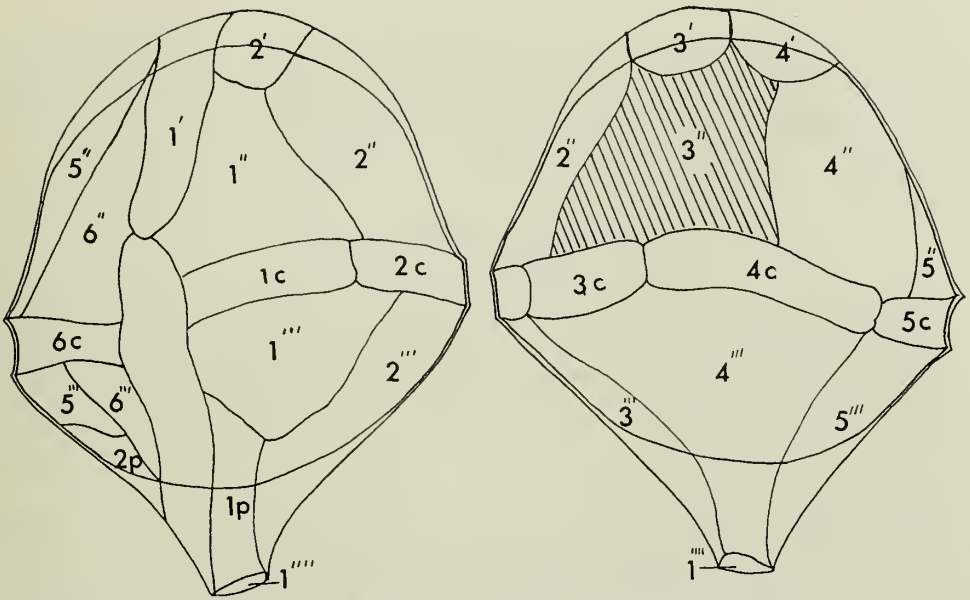


FIG. 18. *Leptodinium egemenii* sp. nov. Tabulation and the archaeopyle formation of the holotype (plate 3″ is missing). Left, ventral view ; right, dorsal view. ×*c.* 1280.

sulcus ; the three other apical plates are more or less uniform in size and smaller than plate 1′. Six precingular plates, without any intercalary plate, together with the apical plates occupy the epitract. Plates 1″ and 2″ are larger than the others ; plate 3″ lost to form the precingular archaeopyle ; plates 4″ and 5″ are elongate, 6″ is approximately triangular in shape.

Six postcingular plates are present : the first (plate 1‴) is small and more or less tetragonal; 2‴ is narrow and elongate, plate 3‴ is also elongate. Plate 4‴ is largest of the postcingular plates. Plate 5‴ is large and P-shaped as a result of the presence of the posterior intercalary plate 2p. Plate 6‴ is smaller of the postcingular plates and triangular-shaped. One of the two posterior intercalary plates, 1p, is elongate and long ; because of its accommodation, plate 1‴ is reduced. Plate 2p is small and placed posterior to plates 5‴ and 6‴. The single antapical plate 1⁗ is very small and flattened.

The sutures are poorly marked by low crests, their distal edge is always smooth.

REMARKS. *L. egemanii* is characterized by its tabulation, lack of an apical horn, and presence of an antapical pericoel. The tabulation was difficult to determine because the crests were poorly marked, and the preservation generally not good. It was observed in the Dorset, Scottish and Le Havre assemblages in moderate abundance.

Although it has a *Gonyaulacysta*-type tabulation, it is not a species of *Gonyaulacysta* because of the absence of an apical horn, according to the emended diagnoses of *Gonyaulacysta* and *Leptodinium* (Sarjeant, 1969) ; it is therefore attributed to the genus *Leptodinium*.

This new species of *Leptodinium* compares with the species of the genus *Psaligonyaulax* and *Tubotuberella*, since it has a pronounced antapical pericoel. In the lack of apical horn and in the detail of the tabulation, it differs from *Psaligonyaulax*. Because Vozzhennikova was unable to give the tabulation of the genus *Tubotuberella*, it is impossible to be certain regarding the generic assignation for this new species.

### *Leptodinium* cf. *subtile* (Klement)

(Pl. 11, figs. 1, 2 ; Text-fig. 19)

Description. This form has a subspherical shell, without apical horn or processes. The cingulum is nearly circular, dividing the theca into two slightly unequal parts, the hypotract being larger than the epitract. Tabulation : 4′, 1a, 6″, 6c, 5″ ′, 2p and 1″ ″. Apical plate 1′ is long and situated in the anterior extension of the sulcus ; the three other apical plates are small. Intercalary plate 1a is placed between plates 4′ and 6″, the latter plate is reduced to accommodate it. The other precingular plates are large.

Three of the postcingular plates (2″ ′, 3″ ′ and 4″ ′) are large ; plates 1″ ′ and 5″ ′ are small because of the intercalary plates 1p and 2p : 1p placed below the first postcingular plate, 2p placed below the fifth postcingular plate. Both of the intercalary plates are rather large. The single antapical plate 1″ ″ is slightly polygonal and convex.

The sutures between the plates, have high, membraneous crests, distal edge of the

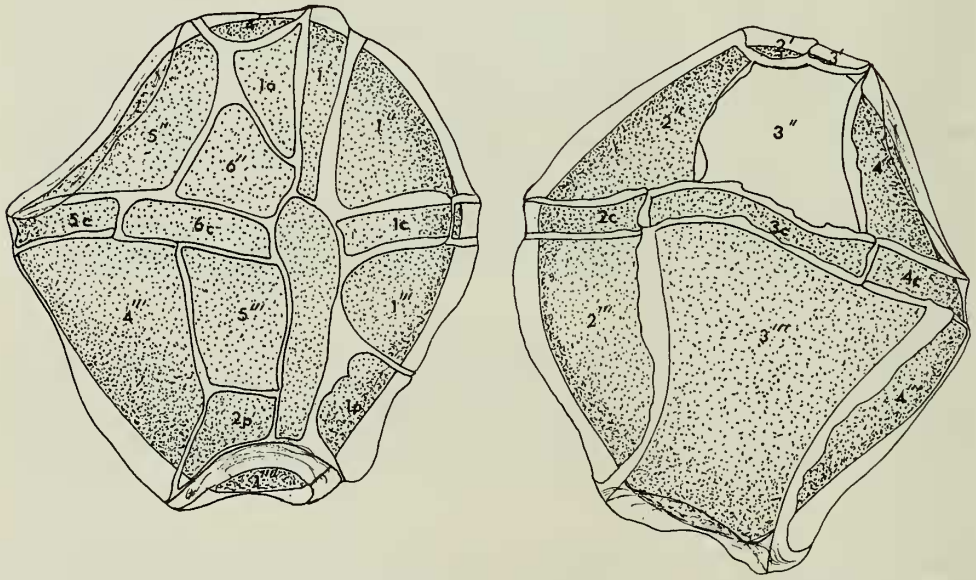


Fig. 19. *Leptodinium* cf. *subtile* (Klement). Tabulation and the archaeopyle formation (plate 3″ is missing). Left, ventral view ; right, dorsal view. ×*c.* 1280.

crests is smooth. The surface of the shell is finely granular. A large precingular archaeopyle is present on the dorsal side, formed by loss of plate 3″.

FIGURED SPECIMEN. BM(NH) slide V.52803(1). Shaly clay from the base of Kimmeridge clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : overall length 80 μ, breadth 85 μ ; shell length 70 μ, breadth 60 μ. Dimensions of the second specimen : length 70 μ, breadth 72 μ. The holotype of *L. subtile* has 74 μ length and 77 μ breadth, as quoted by Klement. In this view there is no difference between English and German specimens.

REMARKS. *L. subtile* has been previously recorded from the Oxfordian of Germany by Klement (1960). Two well-preserved specimens, observed from the Dorset assemblage, correspond in general structure, crests and dimensions to the holotype as figured by Klement ; however, they differ in the detail of the apical plates and the presence of intercalary plate 1a. These specimens are therefore compared with, but not placed in, Klement's species.

## Cyst-Family **MICRODINIACEAE** Eisenack, emend. Sarjeant & Downie, 1966

### Genus ***BELODINIUM*** Cookson & Eisenack, 1960a

#### ***Belodinium dysculum*** Cookson & Eisenack, 1960a

(Pl. 7, fig. 3)

1960a *Belodinium dysculum* Cookson & Eisenack: 250, pl. 37, fig. 14.
1964 *B. dysculum* Cookson & Eisenack ; Downie & Sarjeant: 99.
1964 *B. dysculum* Cookson & Eisenack ; Eisenack: 54.
1964a *B. dysculum* Cookson & Eisenack ; Sarjeant, table 2.
1967a *B. dysculum* Cookson & Eisenack ; Sarjeant, table 2.

REMARKS. A single specimen, observed in the base of Kimmeridgian of Dorset, is closely similar to *B. dysculum*, previously recorded from probable Tithonian of Western Australia by Cookson & Eisenack (1960).

FIGURED SPECIMEN. BM(NH) slide V.52798(1). Shaly clay from the base of Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : overall length 95 μ, breadth 55 μ. This is similar to the holotype dimensions as quoted by Cookson and Eisenack (length 97 μ, breadth 42 μ).

### Genus ***DICTYOPYXIS*** Cookson & Eisenack, 1960b

#### ***Dictyopyxis*** sp.

(Pl. 4, fig. 1)

DESCRIPTION. This form is characterized by the highly reticulate surface. Each small field is separated by high sutures from the others. There is no obvious tabulation ; but some small fields on the equatorial plane together form a median

line, which may well be equivalent to the cingulum of a motile dinoflagellate. The apex is lost in archaeopyle formation.

FIGURED SPECIMEN. BM(NH) slide V.53956(1). Kimmeridge Clay from the west of Osmington Mills, Dorset, which is 20 ft. above the Ringstead Coral Bed (OM 420).

DIMENSIONS. Figured specimen : overall length (apex lacking) 55 $\mu$, breadth 50 $\mu$. Range of the English specimens (4 specimens measured) : overall length (apex lacking) 30–36 $\mu$, breadth 40–42 $\mu$. Single French specimen is overall length (apex lacking) 50 $\mu$, breadth 52 $\mu$.

REMARKS. The specimens observed were generally badly preserved. They differ from previously known species of *Dictyopyxis* (*D. areolata* and *D. reticulata*) and possibly represent a new species, but better specimens are needed before this can be confirmed.

## Genus ***HISTIOPHORA*** Klement, 1960

### ***Histiophora*** cf. ***ornata*** (Klement)

(Pl. 11, fig. 3)

REMARKS. *Histiophora ornata* has previously been recorded from Malm Lower Delta of Germany by Klement (1960). Observed specimens, one from Stretham and two from the Boulonnais, are generally similar to Klement's species, in that they have ellipsoidal shells, bearing four quadrilateral isolated fields, and develop an apical archaeopyle. They differ only in the form of the crests, which are deeply denticulate, having almost the aspect of processes.

FIGURED SPECIMEN. BM(NH) slide V.52964(1). Clay from Argiles de Moulin Wibert, 20 ft. below the top, south side of Cap de La Crèche, Boulonnais (CC 447).

DIMENSIONS. Figured specimen : overall length (apex lacking) 55 $\mu$, breadth 45 $\mu$ ; height of the crests 5–7 $\mu$. The second specimen from the Boulonnais has length 35 $\mu$ (apex lacking) and breadth 32 $\mu$. Length of the Stretham specimen (apex lacking) 35 $\mu$, breadth 35 $\mu$. On both height of the crests 5–7 $\mu$. These are smaller than the German specimen, which was quoted by Klement (length 60 $\mu$, breadth 43 $\mu$).

## Genus ***MEIOUROGONYAULAX*** Sarjeant, 1966

### ***Meiourogonyaulax staffinensis*** sp. nov.

(Pl. 3, fig. 1 ; Text-fig. 20 a, b)

DERIVATION OF THE NAME. Named after the type locality, Staffin Bay, Skye, Scotland.

DIAGNOSIS. *Meiourogonyaulax* having a subspherical to elongate theca, lacking the apex in all specimens seen. Tabulation : ?′, ? 0a, 6″, 6c, 6″ ′, 2p, 1pv and 1″ ″. Crests are moderately high, slightly granulate with smooth distal edges. Cingulum

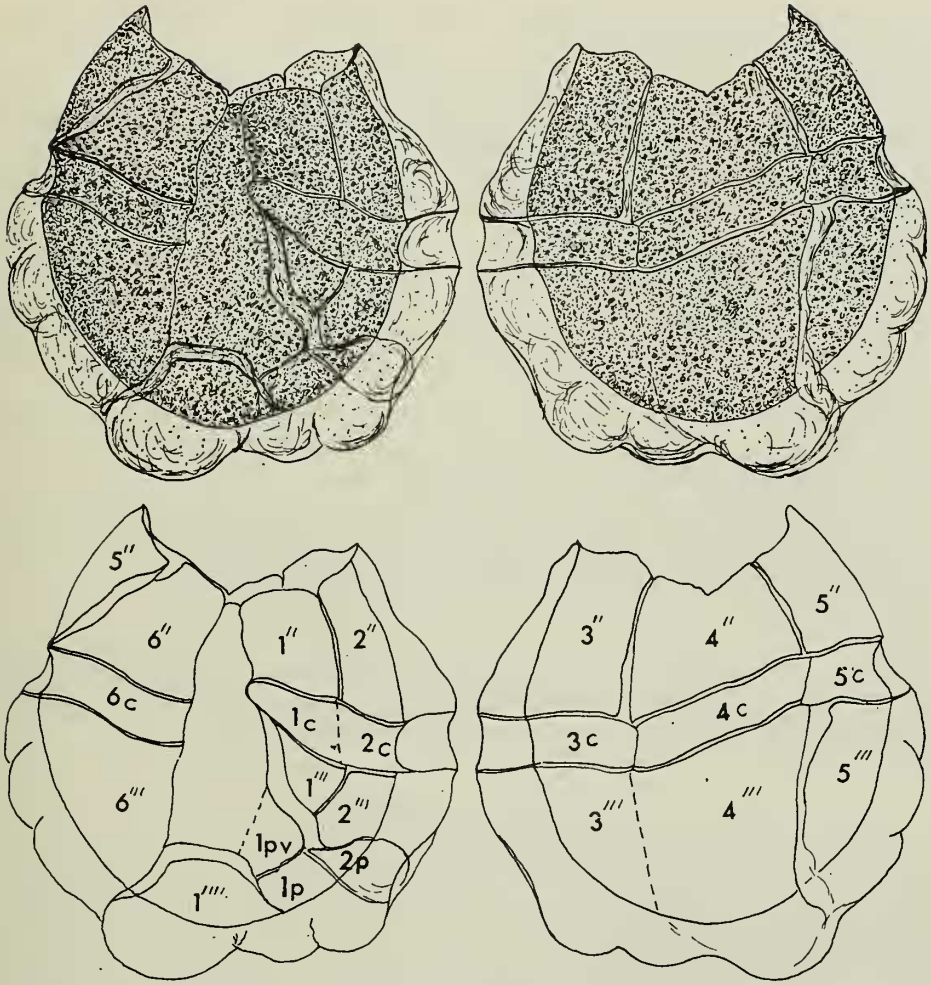


FIG. 20. *Meiourogonyaulax staffinensis* sp. nov. A. General appearance and the apical archaeopyle of the holotype. Left, ventral view ; right, dorsal view. ×*c.* 1320. B. Tabulation (the apical plates are lost in the archaeopyle formation). ×*c.* 1320.

and sulcus are characteristically marked by deep furrows. The cingulum is slightly helicoid, laevorotatory, the sulcus broads towards the antapex. The shell surface is densely granular, sometimes tuberculate.

HOLOTYPE. BM(NH) slide V.53620(1). Shale from 100 ft. above the second dolerite sill, Staffin Bay, Skye (SS 627).

DIMENSIONS. Holotype : overall length (apex lacking) 50 μ, breadth 55 μ ; crests 3–8 μ high ; cingulum *c.* 6 μ broad. Range of the English specimens (7 specimens measured) : overall length (apex lacking) 48–80 μ, breadth 50–78 μ ; French specimens (6 specimens measured) : overall length (apex lacking) 65–75 μ,

breadth 58–80 μ ; Scottish samples (4 specimens measured) : overall length (apex lacking) 50–60 μ, breadth 45–70 μ.

Description. A proximate cyst of subspherical to elongate outline, with a dome-shaped hypotract. Because of the densely granulate surface, determination of the tabulation was difficult. The apex, with all the apical plates, was always lost to form the apical archaeopyle. No intercalary plate was observed. Six precingular plates are present : plate 1″ is the smallest of the precingular plates, the others being almost uniform of size.

Six postcingular plates are also present, plates 1‴ and 2‴ being reduced to accommodate posterior intercalary plates, 1p, 2p and 1pv ; plate 6‴ is much larger. The positions of the boundaries between the plates 3‴ and 4‴, and between the sulcus and plate 1pv, could not be confirmed. The antapex is occupied by a single plate 1⁗.

The cingulum is broad, not less than one tenth of the shell length, being slightly laevorotatory spiral. The sulcus is likewise broad, extending onto both epitract and hypotract, being much broader towards the posterior.

The shell surface is densely granular and sometimes coarsely tuberculate. The tubercles have a diameter of approximately 0·5–1 μ ; they are scattered at random over the generally finely granulate surface.

The crests on the sutures are moderately high, smooth or slightly granulate and faintly striate.

Remarks. Specimens were observed in the assemblages from England, Scotland and France ; they differ in the nature of the crests, surface ornamentation and general aspect from all previously described species of *Meiourogonyaulax*.

### *Meiourogonyaulax* sp.

(Pl. 13, fig. 10, text-fig. 21)

Description. Shell elongate, lacking the apex. Antapex rounded. Without the apex, epitract and hypotract are more or less of the same length. Tabulation : ?4′, 1a, 6″, 6c, 6‴, 1p and 1⁗.

Apical plates are lost in the archaeopyle formation. Plate 1a is located between plates 4′ and 5″, plate 5″ being therefore reduced. First precingular plate 1″ is almost quadrate in shape. The precingular plates on the dorsal side, are larger than the others.

Postcingular plate 1‴ is tetragonal and large. Plate 2‴ being reduced and elongate, separated from the antapex by a posterior intercalary plate (1p). Plate 3‴ is largest of the postcingular plates. Plate 4‴ and 5‴ are reduced, since the large antapical plate 1⁗ occupies a large area. Plate 6‴ is small.

The cingulum is almost planar, occupied by 6 cingular plates of relatively uniform size. The sulcus is broad, extending between apex and antapex.

The crests on the sutures are high and delicate, with smooth or denticulate edges ; around the antapical plate 1⁗ being formed of distally bifid, process like projections.

The surface of the shell is smooth.

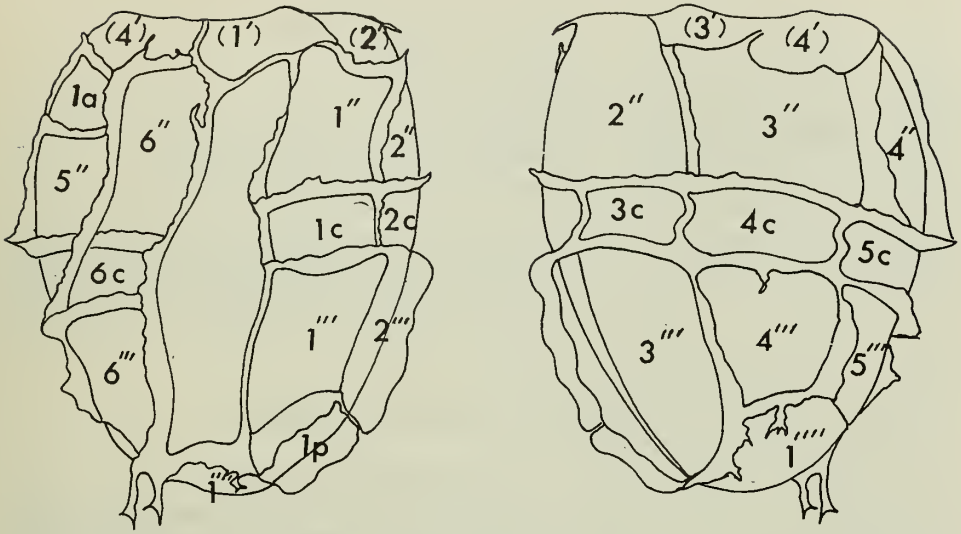


FIG. 21. *Meiourogonyaulax* sp. Tabulation (the apical plates are lost in the archaeopyle formation). Left, ventral view ; right, dorsal view. ×*c.* 1600.

FIGURED SPECIMEN. BM(NH) slide V.53973(1). Shale from 60 ft. above the second dolerite sill, Staffin Bay, Skye (SS 625).

DIMENSIONS. Figured specimen : overall length (apex lacking) 45 μ, breadth 35 μ ; crests 3–6 μ high ; antapical projections length 8 μ. Second specimen overall length (apex lacking) 60 μ, breadth 48 μ ; crests 4–6 μ high.

REMARKS. Two specimens observed were small and transparent, which makes the plates difficult to identify ; the tabulation is also masked by the high crests.

In its small size and apical archaeopyle, it is close to *Microdinium* species, but the number of the apical plates was obviously more than one : from the angular profile of the archaeopyle, the former presence of four apical plates is deduced. This species is accordingly attributed to *Meiourogonyaulax*. The finding of further specimens of this morphological type is necessary before its correct systematic place can be determined and, for this reason, no specific name is given here.

## Cyst-Family **PAREODINIACEAE** Gocht, emend. Sarjeant & Downie, 1966

## Genus ***APTEODINIUM*** Eisenack 1958

### ***Apteodinium granulatum*** Eisenack, 1958

(Pl. 4, fig. 6)

? 1935 *Palaeoperidinium ventriosum* O. Wetzel ; Deflandre: 228, pl. 15, fig. 5.
? 1936 *P. ventriosum* O. Wetzel ; Deflandre: 27, pl. 15, figs. 1–4.
? 1936 *P. ventriosum* O. Wetzel ; Deflandre, fig. 100.
1958 *Apteodinium granulatum* Eisenack: 386, pl. 23, figs. 8–14 ; text-fig. 3.

1959 *A. granulatum* Eisenack ; Gocht: 64, pl. 5, fig. 2; table 1.
1961 *A. granulatum* Eisenack ; Alberti: 24, pl. 4, figs. 4–6, table c.
1963 *A. granulatum* Eisenack ; Balteș: 584, pl. 4, fig. 11.
1964 *A. granulatum* Eisenack ; Downie & Sarjeant: 82.
1964 *A. granulatum* Eisenack ; Eisenack: 37.
1966 *A. granulatum* Eisenack ; Davey, (Ph.D. Thesis): 88–89, pl. 3, figs. 7–9.
1967b *A. granulatum* Eisenack ; Vozzhennikova: 61, pl. 17, fig. 3; table 2.
1967a *A. granulatum* Eisenack ; Sarjeant, table 2.
1969 *A. granulatum* Eisenack; Davey: 130–131, pl. 3, figs. 5, 6.

Description. The spheroidal to ovoidal shell is relatively thick-walled (1·5–2 μ) and bears a strong apical horn. Antapex is rounded. There is no definite indication of tabulation. A cingulum is weakly indicated, sometimes also a sulcus. On the dorsal side a precingular archaeopyle is present, forming by loss of probably plate 3″. The surface is finely granular.

Figured specimen. BM(NH) slide V.53949(1). Kimmeridge Clay from the base, Ringstead Bay, Dorset (RB 219).

Dimensions. Figured specimen : overall length 87 μ, breadth 80 μ ; horn length 13 μ. Range of the English specimens (6 specimens measured) : overall length 80–90 μ, breadth 75–80 μ ; horn length 8–13 μ ; French specimens (6 specimens measured) : overall length 78–83 μ, breadth 70–79 μ. The dimensions of the holotype, as quoted by Eisenack, are length 75 μ, breadth 64 μ ; horn length 12 μ.

Remarks. This proximate cyst has been previously recorded from the Aptian of Germany by Eisenack (1958). In Europe its stratigraphic range extends into the Cenomanian, since Davey observed *A. granulatum* in the English Cenomanian assemblages (1966). Vozzhennikova observed it in assemblages from the Moscow province, for the first time from the Upper Jurassic (Volgian). It is also present in the basal Kimmeridgian assemblages of Dorset, Stretham, Normandy and the Boulonnais, but the specimens were badly preserved.

*Palaeoperidinium ventriosum* O. Wetzel, as figured by Deflandre (1935, 1936), has been compared with *A. granulatum* from Aptian and Cenomanian by Davey (1966). The holotype of *P. ventriosum* O. Wetzel has been re-examined and described as having a distinct tabulation by Lejeune-Carpentier (1946) ; it was designated as *Gonyaulax obscura*. Since the specimens attributed by Deflandre do not possess a tabulation, they have hesitantly been re-attributed to *A. granulatum* by Davey.

### ***Apteodinium*** cf. ***maculatum*** (Cookson & Eisenack)

(Pl. 12, fig. 8)

Description. The nearly spherical shell has a small horn at the apex. There is no indication of a tabulation, cingulum, sulcus or of archaeopyle formation. The surface of the shell is coarsely granular.

Figured specimen. BM(NH) slide V.53970(1). Clay from Grès de Châtillon, south of Audresselles, Boulonnais (CC 450).

Dimensions. Figured specimen : overall length 50 μ, breadth 48 μ. It is smaller than *A. maculatum*, as recorded from the assemblages of Australia. (Range of

dimensions as given by Cookson and Eisenack are length 74–105 μ, breadth 70–105 μ.)

Remarks. One specimen was observed in the assemblage from the Boulonnais which is similar to *A. maculatum*, as recorded from Albian and described by Cookson & Eisenack (1960). It is compared with the latter species, but not placed in it, in absence of knowledge of the possible range of dimensions and of certain major morphologic features and because of the stratigraphic gap : Its observation in the Lower Barremian assemblages from Yorkshire (Sarjeant, 1966) made a considerable extension in the geographic and stratigraphic range of *A. maculatum* ; but still, its presence in the base of the Kimmeridgian is unexpected.

## Genus ***PAREODINIA*** Deflandre, 1947

### ***Pareodinia ceratophora*** Deflandre, 1947

(Pl. 6, figs. 5, 6 ; Pl. 14, fig. 6)

1947 *Pareodinia ceratophora* Deflandre, 4, text-figs. 1–3.
1953 *P. ceratophora* Deflandre ; Valensi: 30, pl. 13, fig. 4.
1959b *P. ceratophora* Deflandre ; Sarjeant: 336–337.
1961a *P. ceratophora* Deflandre ; Sarjeant: 99, pl. 13, fig. 6; text-fig. 15.
1961 *P. ceratophora* Deflandre ; Alberti: 23, pl. 12, fig. 14; table d.
1962a *P. ceratophora* Deflandre ; Sarjeant: 263, pl. 1, fig. 13, tables 3, 4.
1962b *P. ceratophora* Deflandre ; Sarjeant: 483, pl. 69, fig. 8 ; text-fig. 5.
1964 *P. ceratophora* Deflandre ; Downie & Sarjeant: 138.
1964 *P. ceratophora* Deflandre ; Eisenack: 633.
1964a *P. ceratophora* Deflandre ; Sarjeant, table 2.
1965 *P. ceratophora* Deflandre ; Sarjeant, table 1.
1966 *P. ceratophora* Deflandre ; Schulz & Mai, table 1.
1967b *P. ceratophora* Deflandre ; Sarjeant, table 2.
1968 *P. ceratophora* Deflandre ; Sarjeant, table 2A.

Remarks. This species was first recorded from the Callovian of the Baltic region and Bajocian of France by Deflandre (1947). In England it has been recorded from Middle Callovian to Upper Oxfordian (Sarjeant, 1961, 1962). It occurs in moderate abundance in the assemblages from the base of the Kimmeridgian of France, England and Scotland.

Figured specimens. BM(NH) slide V.52802(1). Shaly clay from base of the Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

BM(NH) slide V.53938(1). Clay from Exogyra Marls, 1 m. above the Upper Hard Band, Cap de la Hève, Le Havre (CH 185).

BM(NH) slide V.53948(1). Clay from *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset (RB 219).

Dimensions. Range of the English specimens (42 specimens measured) : overall length 45–110 μ, breadth 32–80 μ ; horn length 8–25 μ. French specimens (31 specimens measured) : overall length 58–96 μ, breadth 42–76 μ ; horn length 7–23 μ. Scottish specimens (5 specimens measured) : overall length 60–75 μ, breadth 32–60 μ ; horn length 8–15 μ.

## Genus *TRICHODINIUM* Eisenack & Cookson, 1960

### *Trichodinium* sp.

(Pl. 4, fig. 2)

Description. A proximate cyst having a broadly ovoidal shell with a short, branched apical horn. There is no indication of a longitudinal furrow and no definite tabulation ; the rather distinct cingulum is equatorial and almost plannar.

The shell membrane is relatively thick (*c.* 1·5–2 $\mu$) ; its surface is granular, bearing processes at random, which are solid, simple conical or rarely branched, generally broad-based.

No archaeopyle was observed in the specimen studied.

Figured specimen. BM(NH) slide V.53960(1). Clay from Great Ouse River Board Pit, Stretham, Cambridgeshire (SC 444).

Dimensions. Figured specimen : overall length 53 $\mu$, breadth 45 $\mu$ ; horn length 6 $\mu$ ; length of the processes 5–8 $\mu$.

Remarks. This observation was based on a single, but well preserved specimen. It is characterized by bearing processes over the whole shell surface. It differs from all described species of the genus in the form and distribution of its processes and in the absence of an archaeopyle ; and it obviously represents an undescribed species of this genus ; for fuller knowledge, further and better specimens must be awaited.

## Cyst-Family uncertain

## Genus *IMBATODINIUM* Vozzhennikova, 1967b

Translation of original diagnosis. The shell is strongly elongate, laterally slightly compressed. The cingulum may be shallow or deep and is displaced towards the posterior end of the cell.

The sulcus is curved and S-shaped, shallow or deep, and extends from the base of the apical horn to the end of the antapex. The epitract is big, with a finger-shaped apical horn, on the distal end of which there is often a fibre-like growth tentacle finishing in a small bulge of button-like appearance. The hypotract represents $\frac{1}{3}$–$\frac{1}{4}$ of the length of the shell, with a small antapical projection, uniform or variable in form and size. The wall is typically thin, more rarely thick. The surface is smooth, grainy, knobbly or covered with fibres, small spines or other growths. The archaeopyle is oval in shape and intercalary in position.

Type species. *Imbatodinium kondratjevi* Vozzhennikova. Upper Jurassic western Siberia (Verkhnye-Imbatskoye).

Remarks. Since the diagnosis of this genus has only previously been published in Russian, a translation is given here.

### *Imbatodinium* sp.

(Pl. 7, fig. 5)

DESCRIPTION. A proximate cyst, ovoidal in shape, with a finger-shaped apical horn. There is no definite indication of tabulation or of a sulcus ; the cingulum is weakly developed. The epitract is longer than the hypotract, which is almost $\frac{3}{4}$ of the overall length. The surface of the shell is coarsely granular. An intercalary archaeopyle was seen on the epitract of one specimen.

FIGURED SPECIMEN. BM(NH) slide V.52799(2). Shaly clay from *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : overall length 80 $\mu$, breadth 45 $\mu$ ; horn length 12 $\mu$. Second specimen overall length 75 $\mu$, breadth 38 $\mu$ ; horn length 18 $\mu$.

REMARKS. Two specimens, observed in the basal Kimmeridgian assemblages, are similar to the species of *Pareodinia*, but their apical horn is different. These specimens are possibly representatives of an undescribed species of *Imbatodinium*, since they differ from existing species in the characteristics above described. Further and better specimens are required before this can be decided.

## Genus ***NANNOCERATOPSIS*** Deflandre, 1938a

### ***Nannoceratopsis pellucida*** Deflandre, 1938a

(Pl. 7, fig. 4)

1938a *Nannoceratopsis pellucida* Deflandre, 183: pl. 8, fig. 10.
1952 *N. pellucida* Deflandre ; Deflandre, fig. 81.
1958 *N. pellucida* Deflandre ; Cookson & Eisenack: 52, pl. 10, figs. 5, 6 ; text-fig. 19.
1960 *N. pellucida* Deflandre ; Sarjeant: 392, pl. 12, figs. 7–10.
1961b *N. pellucida* Deflandre ; Evitt: 312, pl. 1, fig. 15 ; pl. 2, figs. 30–31.
1962a *N. pellucida* Deflandre ; Sarjeant, tables 3, 4.
1962b *N. pellucida* Deflandre ; Sarjeant, pl. 69, figs. 9–10 ; tables 2, 3.
1964 *N. pellucida* Deflandre ; Downie & Sarjeant: 134.
1964 *N. pellucida* Deflandre ; Eisenack: 535–536.
1964a *N. pellucida* Deflandre ; Sarjeant, table 2.
1966 *N. pellucida* Deflandre ; Schulz & Mai, table 1.
1967b *N. pellucida* Deflandre ; Sarjeant, table 4.

REMARKS. This species has been recorded from Oxfordian to Lower Kimmeridgian of Australia and Europe. Two specimens were observed in the Dorset assemblages only.

FIGURED SPECIMEN. BM(NH) slide V.52800(2). Shaly clay from the base of Kimmeridge Clay, *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : overall length 120 $\mu$, breadth 55 $\mu$ ; apical horn length 12 $\mu$, antapical horn length 40 $\mu$. Second specimen : overall length 115 $\mu$, breadth 60 $\mu$ ; apical horn length 10 $\mu$, antapical horns length 36 $\mu$.

Cyst-family **HYSTRICHOSPHAERIDIACEAE** Evitt, emend. Sarjeant & Downie, 1966

Genus ***CLEISTOSPHAERIDIUM*** Davey, Downie, Sarjeant & Williams, 1969

***Cleistosphaeridium ehrenbergi*** (Deflandre) Davey, Downie, Sarjeant & Williams, 1969

(Pl. 4, fig. 7 ; Text-fig. 22a)

1938a *Hystrichosphaeridium* cf. *hirsutum* Deflandre, pl. 10, fig. 9.
1947 *Hystrichosphaeridium ehrenbergi* Deflandre, fig. 1, no. 5.
1952 *H. ehrenbergi* Deflandre ; fig. 9.
1955 *H. ehrenbergi* Deflandre ; Valensi: 587, pl. 3, fig. 1.
1963 *Baltisphaeridium ehrenbergi* (Deflandre) ; Sarjeant: 486–487, pl. 70, fig. 1 ; text-fig. 6a.
1964 *B. ehrenbergi* (Deflandre) ; Downie & Sarjeant: 90.
1964a *B. ehrenbergi* (Deflandre) ; Sarjeant, table 3.
1966 *Cleistosphaeridium ehrenbergi* (Deflandre) ; Davey, Downie, Sarjeant and Williams, *nomen nudum*, 170.
1967a *C. ehrenbergi* (Deflandre) ; Sarjeant, table 5, *nomen nudum*.
1968 *C. ehrenbergi* (Deflandre) ; Sarjeant, table 2B, *nomen nudum*.
1969 *C. ehrenbergi* (Deflandre) ; Davey, Downie, Sarjeant & Williams (in press).

DESCRIPTION. The subspherical shell bears simple straight, solid, conical and distally closed processes in large number (30–44). The shell surface is smooth. Sometimes an apical archaeopyle is developed.

FIGURED SPECIMEN. BM(NH) slide V.52801(1). Shaly clay from the base of Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : shell length 35 $\mu$, breadth 38 $\mu$ ; process length 15–18 $\mu$. Range of the English specimens (9 specimens measured) : shell length 45–62 $\mu$, breadth 45–50 $\mu$ ; French specimens (2 specimens measured) : shell length 48–65 $\mu$, breadth 45–50 $\mu$. In all specimens, length of the process 15–25 $\mu$, breadth 1·5 $\mu$. Dimensions of the Scottish specimen : shell length 30 $\mu$, breadth 30 $\mu$ ; process length 16 $\mu$.

REMARKS. This chorate cyst has previously been recorded from the Lower Oxfordian of Normandy and England. It is abundant in the Dorset assemblages, but rare in Scottish and French material.

***Cleistosphaeridium polyacanthum*** sp. nov.

(Pl. 12, fig. 10 ; Text-fig. 22b)

DERIVATION OF THE NAME. Greek, *polys*, many, very ; and *acanthus*, thorny, with reference to the number of the processes of the shell.

DIAGNOSIS. A *Cleistosphaeridium* having an ellipsoidal to ovoidal shell bearing numerous processes (50–70 in number). All processes of approximately same length (not less than half of the shell length), simple, straight, hollow and acuminate. Shell surface smooth. Apical archaeopyle sometimes present.

HOLOTYPE. BM(NH) slide V.53943(1). Kimmeridge Clay from between the Ringstead Waxy Clay and the Coral bed, Ringstead Bay, Dorset (RB 218).

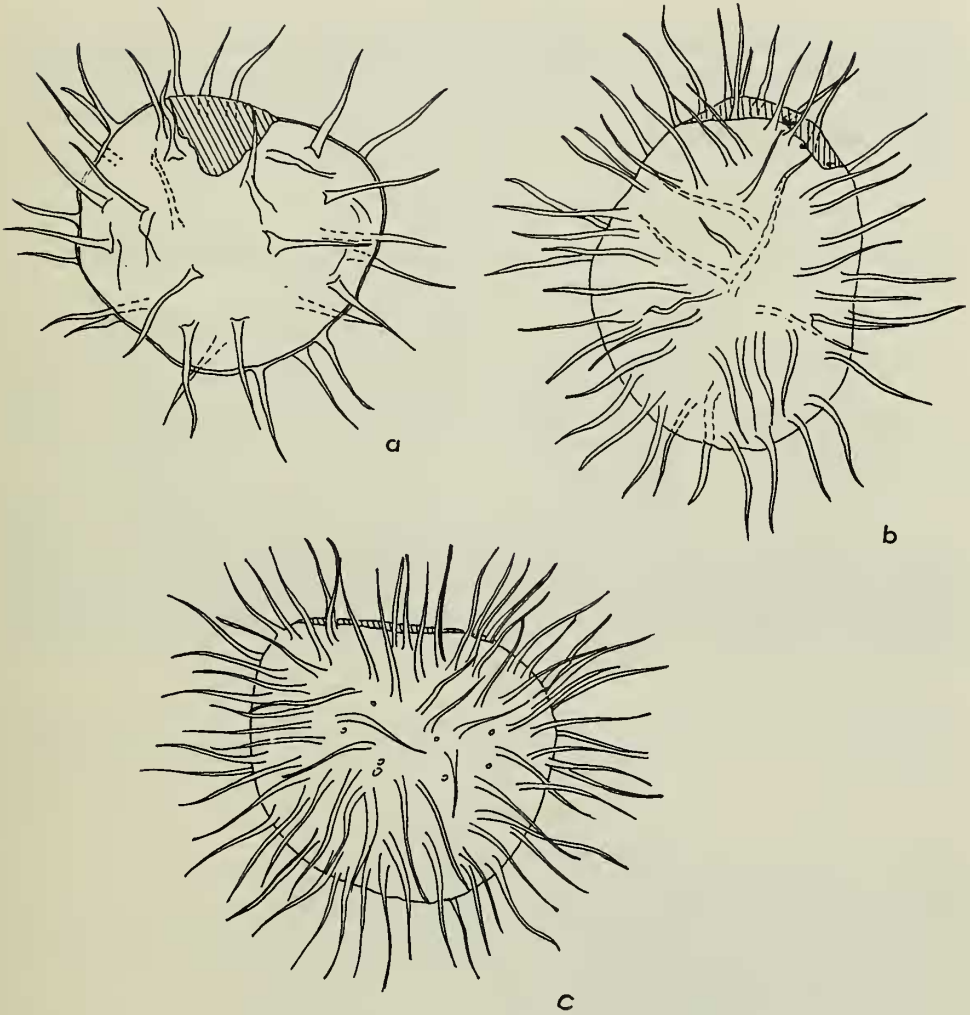


FIG. 22. Three similar species of *Cleistosphaeridium*. A. *Cleistosphaeridium ehrenbergi* (Deflandre). ×*c.* 1280. B. *Cleistosphaeridium polyacanthum* sp. nov. Holotype. ×*c.* 1400. C. *Cleistosphaeridium polytrichum* (Valensi). ×*c.* 1280.

DIMENSIONS. Holotype : shell length 40 μ, breadth 30 μ ; length of the processes 20–22 μ. Range of the English specimens (5 specimens measured) : shell length 33–42 μ, breadth 28–35 μ ; French specimens (4 specimens measured) : shell length 30–45 μ, breadth 25–38 μ ; length of the processes 16–20 μ.

DESCRIPTION. This chorate cyst has processes in variable number, 50–70, their cavity directly connected to the shell interior. There are no fields or plates identifiable on the shell.

Remarks. This new form of *Cleistosphaeridium* should be placed morphologically between *C. ehrenbergi* and *C. polytrichum*. It differs from them consistently in shell shape and in the number of the processes. These three species do not seem to be part of a continuously varying plexus, at least at this horizon, since intermediate forms were not encountered (Table 5).

Table 5
Comparison of dimensions of three similar species of *Cleistosphaeridium*

| | Dimensions | Length of Processes | Thickness of Processes | Number of Processes |
|---|---|---|---|---|
| *C. ehrenbergi* | Length 30–65 μ<br>Breadth 30–50 μ | 15–25 μ | 1·5 μ | 30–44 μ |
| *C. polyacanthum* | Length 30–45 μ<br>Breadth 25–38 μ | 16–20 μ | 1 μ | 50–70 μ |
| *C. polytrichum* | Length 28–30 μ<br>Breadth 33–35 μ | 12–15 μ | 1·2 μ | 86–100 μ |

*C. polyacanthum* is comparable with *C. flexuosum*, which was recorded from Cenomanian of England by Davey, Downie, Sarjeant & Williams (1966), in its ovoidal shape and simple acuminate processes in large number. Since the processes of *C. flexuosum* are slightly fibrous and always flexuous, this new species is different ; moreover, archaeopyle formation was not observed in *C. flexuosum*.

### ***Cleistosphaeridium polytrichum*** (Valensi), Davey, Downie, Sarjeant & Williams, 1969

(Pl. 4, fig. 4 ; Text-fig. 22c)

1947 *Hystrichosphaeridium polytrichum* Valensi, fig. 4.
1953 *H. polytrichum* Valensi ; Valensi, pl. 4, fig. 6 ; pl. 13, fig. 12.
1955 *H. polytrichum* Valensi ; Deflandre & Cookson, pl. 2, fig. 2.
1962b *Baltisphaeridium polytrichum* (Valensi) ; Sarjeant: 487, pl. 70, fig. 2 ; text-fig. 66.
1963 *Hystrichosphaeridium polytrichum* Valensi ; Górka, pl. 9, figs. 1–3.
1964 *Baltisphaeridium polytrichum* (Valensi) ; Downie & Sarjeant: 95.
1964a *B. polytrichum* (Valensi) ; Sarjeant, table 3.
1966 *B. polytrichum* (Valensi) ; Schulz & Mai, table 1.
1966 *Cleistosphaeridium polytrichum* (Valensi) ; Davey, Downie, Sarjeant & Williams, *nomen nudum*: 170.
1967a *C. polytrichum* (Valensi) ; Sarjeant, table 5, *nomen nudum*.
1968 *Baltisphaeridium polytrichum* (Valensi) ; Horowitz: 55, pl. 7, fig. 7 ; table 3.
1969 *Cleistosphaeridium polytrichum* (Valensi) ; Davey, Downie, Sarjeant & Williams (in press).

Description. The subspherical shell bears a large number of processes (about 86–100) ; they are simple, conical, solid and distally closed. An apical archaeopyle is usually present.

Figured specimen. BM(NH) slide V.52799(3). Shaly clay from the base of Kimmeridge Clay, *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

Dimensions. Figured specimen : shell length (apex lacking) 28 $\mu$, breadth 35 $\mu$ ; process length 12–15 $\mu$, breadth 1·2 $\mu$. Range : (5 specimens measured) : shell length 28–35 $\mu$, breadth 33–35 $\mu$ ; process length 12–15 $\mu$.

Remarks. *C. polytrichum* has previously been recorded from the Bathonian of France, the Oxfordian and Kimmeridgian of England. It was observed in the basal Kimmeridgian from Dorset assemblages only.

### ***Cleistosphaeridium tribuliferum*** (Sarjeant), Davey, Downie, Sarjeant & Williams, 1969

(Pl. 9, fig. 2 ; Pl. 12, fig. 9 ; Text-fig. 23)

1962b *Baltisphaeridium tribuliferum* Sarjeant: 487–488, pl. 70, fig. 4 ; text-figs. 6c, 7.
1964 *B. tribuliferum* Sarjeant ; Downie & Sarjeant: 97.
1964a *B. tribuliferum* Sarjeant ; Sarjeant, table 3.
1966 *Cleistosphaeridium tribuliferum* (Sarjeant) ; Davey, Downie, Sarjeant & Williams, *nomen nudum*, 170.
1967a *C. tribuliferum* (Sarjeant) ; Sarjeant, table 5, *nomen nudum*.
1968 *C. tribuliferum* (Sarjeant); Sarjeant, table 2B, *nomen nudum*.
1969 *C. tribuliferum* (Sarjeant) ; Davey, Downie, Sarjeant & Williams (in press).

Description. The central body is subspherical to ovoidal in shape, bearing moderately numerous processes. The processes are conical, hollow, distally closed

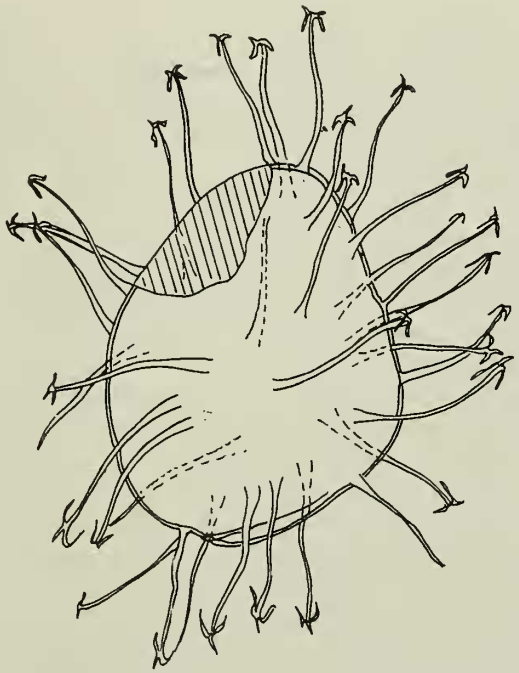

Fig. 23. *Cleistosphaeridium tribuliferum* (Sarjeant). A specimen from the basal Kimmeridgian of Ringstead Bay. ×*c.* 1280.

and recurved, between 28–60 in number. The surface of the shell is smooth. An apical archaeopyle is present.

FIGURED SPECIMENS. BM(NH) slide V.53951(1) and V.53978(1). Both specimens from immediate base of the Kimmeridge Clay, *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset (RB 219).

DIMENSIONS. Range of the English specimens (20 specimens measured) : shell length 33–62 $\mu$, breadth 25–53 $\mu$ ; process length 17–35 $\mu$. Dimensions of the single Scottish specimen observed : shell length 35 $\mu$, breadth 33 $\mu$ ; process length 15 $\mu$.

REMARKS. *C. tribuliferum* has previously been recorded from the Ampthill Clay and Oxford Clay of England (Oxfordian) by Sarjeant. It is abundant in Dorset assemblages, but only one specimen was observed in the Scottish material, none from France.

*C. tribuliferum* is comparable in general appearance and by its similar processes with *Hystrichosphaeridium recurvatum*, which has hollow, distally open, recurved or aculeate processes ; but *C. tribuliferum* possesses processes in larger number which are distally closed.

### *Cleistosphaeridium* sp.

(Pl. 1, fig. 7)

DESCRIPTION. A chorate dinoflagellate cyst having a subspherical to ovoidal shell bearing numerous processes, typically closed distally and without communication to the endocoel. The number of processes is about 70–80 ; they are simple, broad based, oblate and short ($\frac{1}{3}$ of the shell breadth). The surface of the shell is finely granular. An apical archaeopyle is present.

FIGURED SPECIMEN. BM(NH) slide V.53958(1). Clay from 20 ft. above Ringstead Coral Bed, west of Osmington Mills, foreshore exposure, Dorset (OM 420).

DIMENSIONS. Figured specimen : shell length (apex lacking) 38 $\mu$, breadth 40 $\mu$ ; process length 8–10 $\mu$, breadth (at the base) 3–3·5 $\mu$, (at the top) 1–1·5 $\mu$. Dimensions of the French specimens (2 specimens measured) : shell length 38–55 $\mu$, breadth 45–55 $\mu$ ; process length 5–10 $\mu$.

Dimensions of the Dorset specimen : shell length (apex lacking) 38 $\mu$, breadth 45 $\mu$ ; process length 8–10 $\mu$. Scottish specimen's length 50 $\mu$, breadth 43 $\mu$.

REMARKS. Five specimens were recorded from the basal Kimmeridgian assemblages, which are different from all previously known species of the genus in the nature of their processes. These specimens, with their broad-based, oblate processes and finely granular surface, are closest to *Exochosphaeridium pseudhystrichodinium* ; this species was originally recorded from the Upper Cretaceous by Deflandre (1937), as *Hystrichosphaeridium pseudhystrichodinium*, and tentatively re-attributed to the genus *Exochosphaeridium* by Davey, Downie, Sarjeant & Williams (1966). They differ, however in their mode of archaeopyle formation : *E. pseudhystrichodinium* has a precingular archaeopyle, but *Cleistosphaeridium* sp. has an apical archaeopyle.

Genus ***HYSTRICHOSPHAERIDIUM*** Deflandre, emend. Davey & Williams (in Davey, Downie, Sarjeant & Williams), 1969

***Hystrichosphaeridium petilum*** sp. nov.

(Pl. 9, figs. 1, 6 ; Text-fig. 24)

Derivation of the name. Latin, *petilus*, thin, slender, with reference to the thin-walled shell.

Diagnosis. A *Hystrichosphaeridium* having a subspherical delicate thin-walled shell. Processes very slender, tubular, open distally, with 4–6 aculeate spines around the process mouths. Reflected tabulation : 4′, 6″, 6c, 0–1s, 6″′, 1p and 1″″. Surface of the shell smooth. An apical archaeopyle is usually present.

Holotype. BM(NH) slide V.53944(1). Clay from between Ringstead Waxy Clay and Ringstead Coral Bed, Ringstead Bay, Dorset (RB 218).

Dimensions. Holotype : shell length (apex lacking) 35 μ, breadth 35 μ ; process length 17–20 μ, breadth up to 3 μ. Range of the English specimens (20 specimens measured) : length 30–35 μ, (apex lacking) 28 μ, breadth 25–35 μ. French specimens (2 specimens measured) : length 33–35 μ, breadth 25–35 μ. Scottish specimens (10 specimens measured) : length 22–32 μ, (apex lacking) 20–30 μ, breadth 16–35 μ ; process length 12–20 μ.

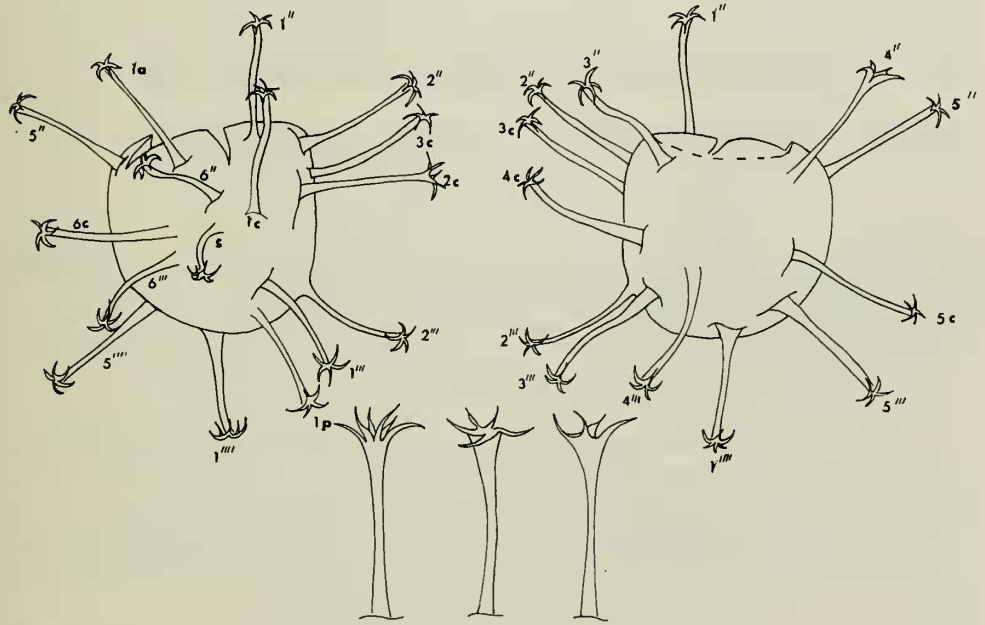


Fig. 24. *Hystrichosphaeridium petilum* sp. nov. Tabulation of the holotype. Upper left, ventral view ; upper right, dorsal view (by transparency). ×*c.* 1280. Lower centre, the processes. ×*c.* 1830.

Description. The central body and the processes are characteristically thin-walled. The central body is composed of two membranes, an inner endophragm and an outer periphragm, the periphragm only comprising the processes. The tubular processes are usually curved or bent to some extent, probably as a result of preservation. They are usually, at least, two-thirds of the shell length. The spines on the tube mouths are up to 4 $\mu$ in length and 4–6 in number. An apical archaeopyle is usually present, formed by loss of the apex with four apical processes.

Remarks. This new chorate cyst was attributed to *Hystrichosphaeridium* without hesitation in view of the features described above. It is similar to *H. tubiferum*, *H. recurvatum*, *H. bowerbanki* and *H. sheppeyense*, but differs in details and the number of the processes : *H. tubiferum* has 4–5 sulcal processes, whereas in *H. petilum* either only one sulcal process or none at all are present. The processes of *H. tubiferum* are thicker and distally have an entire or serrate circular margin. *H. recurvatum* has 3–6 sulcal processes. The processes of *H. sheppeyense* are relatively thick-walled and, at the base of some of the processes, there are small proximal elevations or swellings. *H. bowerbanki* is ovoidal to elongate in shape and has 5 sulcal processes. *H. petilum* therefore is significantly different from all these species. It was observed in the basal Kimmeridgian assemblages from England, Scotland and France in moderate number.

## Genus ***OLIGOSPHAERIDIUM*** Davey & Williams, 1966

### ***Oligosphaeridium pulcherrimum*** (Deflandre & Cookson), Davey & Williams (in Davey, Downie, Sarjeant & Williams), 1966

(Pl. 7, fig. 7)

1955 *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson: 270, pl. 1, fig. 8 ; text-fig. 21.
1955 *H. pulcherrimum* Deflandre & Cookson ; Valensi: 592, pl. 4, fig. 1.
1964 *H. pulcherrimum* Deflandre & Cookson ; Downie & Sarjeant: 121.
1966 *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) ; Davey & Williams: 75–76, pl. 10, fig. 9 ; pl. 11, fig. 5.
1967b *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) ; Sarjeant, table 6.

Remarks. This species was first recorded from the Lower Cretaceous of Australia. In England it has been recorded from the London Clay. It was observed in Dorset and the Boulonnais assemblages, but all specimens are badly preserved.

Figured specimen. BM(NH) slide V.53946(1). Clay from immediately base of the Kimmeridge Clay, *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset (RB 219).

Dimensions. Figured specimen : shell length 50 $\mu$, breadth 48 $\mu$, process length 18–35 $\mu$. The other three specimens were not measured because of their poor preservation.

## Genus *POLYSTEPHANEPHORUS* Sarjeant, 1961

### *Polystephanephorus sarjeantii* sp. nov.

(Pl. 11, fig. 4 ; Text-fig. 25)

Derivation of the name. Named in honour of Dr. William A. S. Sarjeant, who established the genus.

Diagnosis. *Polystephanephorus* having a spherical to subspherical shell, bearing 14 groups of processes together with 2 single processes. There is no connection between the adjacent groups. All processes of each group are connected distally by a ring trabecula. The number of the processes in the groups is variable, between 2 and 6. Reflected tabulation : ?', 6", 6" ', 1p, 2s and 1" ". Surface of the shell smooth and transparent. Apical archaeopyle developed.

Holotype. BM(NH) slide V.52792(2). Shaly clay from the base of the Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

Dimensions. Holotype : shell length 40 $\mu$, breadth 45 $\mu$ ; process length 20–25 $\mu$. Range of the English specimens (10 specimens measured) : shell length 40–70 $\mu$, breadth 35–60 $\mu$ ; process length 20–28 $\mu$. French specimens (6 specimens measured) : shell length 42–60 $\mu$, breadth 40–55 $\mu$ ; process length 22–28 $\mu$.

Description. Central body subspherical or spherical in shape, with groups of complicated processes. In addition to the groups of processes, two single processes were observed, which are positional equivalents of the sulcus. These two single processes are foliate and furcate towards their distal ends. All the processes of each group separately rise up from the central body and are subsequently connected by

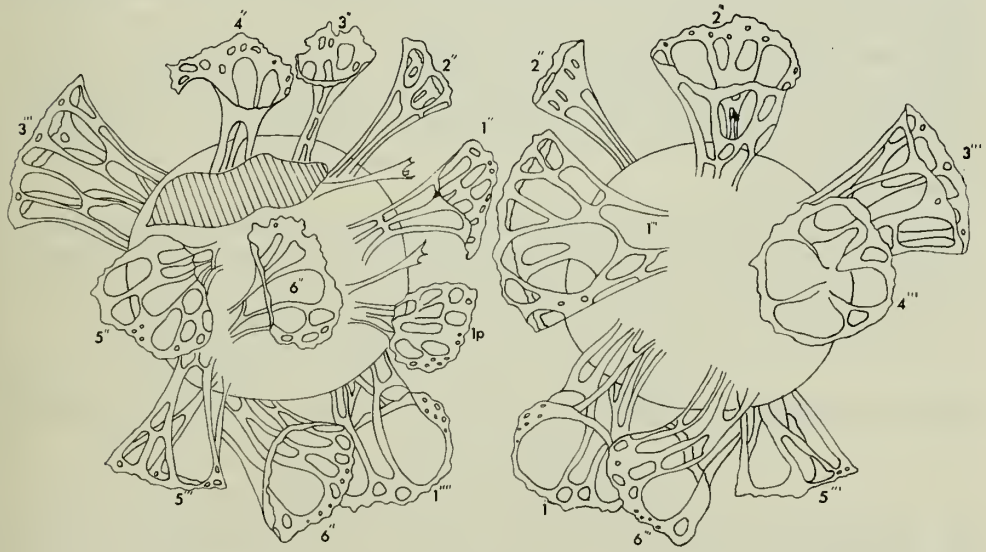


Fig. 25. *Polystephanephorus sarjeantii* sp. nov. Holotype, showing the tabulation. Left, ventral view ; right, dorsal view (by transparency). ×*c.* 1530.

bridge-like strands ; near to their tips, they are foliate and fenestrate ; at their tips, they are connected by a ring trabecula with denticulate edges. All the processes are solid.

The surface of the shell appears smooth and transparent ; because of their transparency, identification of the processes was extremely difficult. An apical archaeopyle, slightly polygonal in shape, was seen in some of the specimens studied.

Remarks. This new species of the genus *Polystephanephorus* differs from the previously described species in its more complicated processes. The processes are not connected proximally, as in *P. urnaformis*, and the branches are longer than the branches of *P. calathus* and *P. paracalathus* ; they are not directed parallel to the shell surface ; however the processes are linked by a ring trabecula as the other species of the genus.

*P. sarjeantii* is similar to *Adnatosphaeridium caulleryi*, but the arrangement and the manner of linkage of the processes are different.

This new species was observed in moderate number in the assemblages from Dorset and the Boulonnais, but none from Scotland.

## Genus ***PROLIXOSPHAERIDIUM*** Davey, Downie, Sarjeant & Williams, 1966

### ***Prolixosphaeridium*** cf. ***deirense*** (Davey, Downie, Sarjeant & Williams)

(Pl. 13, fig. 9)

Description. This chorate cyst is elongate to ovoidal in shape. The apical pole is lost to form the archaeopyle. The shell is thick-walled and granular, bearing simple, solid, conical processes, about 46 in number.

Figured specimen. BM(NH) slide V.53950(1). Clay from Ringstead Bay, *Rhactorhynchia inconstans* Bed, Dorset (RB 219).

Dimensions. Figured specimen : shell length (apex lacking) 55 $\mu$, breadth 37 $\mu$ ; length of the processes 12–15 $\mu$. The other specimen length 69 $\mu$, breadth 42 $\mu$ ; process length 14–16 $\mu$.

Remarks. Two specimens observed from the Dorset assemblages were similar to *P. deirense*, as described by Davey, Downie, Sarjeant & Williams (1966). However the enlarged antapical processes were not clear and the other processes did not appear to be arranged in rows ; therefore the species assignation remains uncertain.

### ***Prolixosphaeridium granulosum*** (Deflandre), Davey, Downie, Sarjeant & Williams, 1966

(Pl. 2, fig. 6 ; Pl. 5, fig. 3 ; Pl. 13, fig. 7)

1935 *Hystrichosphaera xanthiopyxides* Deflandre, pl. 9, fig. 7.
1937 *Hystrichosphaeridium xanthiopyxides* var. *granulosum* (Deflandre) ; Deflandre: 29, pl. 16, fig. 4.
1955 *H. xanthiopyxides* var. *granulosum* (Deflandre) ; Valensi: 589, pl. 3, fig. 7 ; pl. 5, fig. 16.

1957 *H. xanthiopyxides* var. *granulosum* (Deflandre) ; Downie: 426, text-fig. 49.
1960 *Baltisphaeridium xanthiopyxides* var. *granulosum* (Deflandre) ; Klement: 59.
1962a *Baltisphaeridium granulosum* (Deflandre) ; Sarjeant: 264, pl. 2, fig. 14 ; text-fig. 8c ; tables 3, 4.
1964 *B. granulosum* (Deflandre) ; Downie & Sarjeant: 91.
1964a *B. granulosum* (Deflandre) ; Sarjeant, table 3.
1966 *Prolixosphaeridium granulosum* (Deflandre) ; Davey, Downie, Sarjeant & Williams: 172–173.
1967 *Baltisphaeridium granulosum* (Deflandre) ; Clarke & Verdier: 74, pl. 12, figs. 7–9.
1967b *Prolixosphaeridium granulosum* (Deflandre) ; Sarjeant, table 7.

Remarks. This species has a known range from Oxfordian to Eocene. Deflandre first observed it in Cretaceous (?Aptian) flints from France (1937). Valensi described specimens of larger size from Cretaceous flints (1955). A closely similar form was recorded from the Kimmeridgian by Downie (1957), which was the first English and Jurassic specimen ; widening the geographic and stratigraphic range. Subsequently more representatives of *P. granulosum* were recorded from the Ringstead Waxy Clay (Oxfordian ; Sarjeant, 1962a) and the Eocene London Clay (1966) ; both from southern England. It was observed in the basal Kimmeridgian assemblages from England, Scotland and France in moderate abundance.

Figured specimens. BM(NH) slide V.52799(4). Shaly clay from *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

BM(NH) slide V.53960(2). Clay from Great Ouse River Board Pit, Stretham, Cambridgeshire (SC 444).

Specimen RB 218/12–215 ; clay from between the Ringstead Waxy Clay and Ringstead Coral Bed, Ringstead Bay, Dorset (RB 218).

Dimensions. Range of the English specimens (24 specimens measured) : shell length (apex lacking) 45–55 μ, with apex 40–62 μ, breadth 18–35 μ, process length 8–12 μ. French specimens (4 specimens measured) : shell length 38–58 μ, breadth 20–35 μ ; process length 9–11 μ. Dimensions of the Scottish specimens (10 specimens measured) : shell length 45–50 μ, (apex lacking) 30–55 μ, breadth 25–35 μ ; process length 6–18 μ.

### ***Prolixosphaeridium parvispinum*** (Deflandre), Davey, Downie, Sarjeant & Williams, 1966

(Pl. 2, fig. 3)

1937 *Hystrichosphaeridium xanthiopyxides* var. *parvispinum* Deflandre: 29, pl. 16, fig. 5.
1941 *H. xanthiopyxides* var. *parvispinum* Deflandre ; Conrad: 2.
1952 *H. xanthiopyxides* var. *parvispinum* Deflandre ; Deflandre, fig. 13.
1958 *Histrichosphaeridium parvispinum* (Deflandre) ; Cookson & Eisenack: 45, pl. 7, figs. 10–12.
1960 *Baltisphaeridium parvispinum* (Deflandre) ; Klement: 59.
1962b *B. parvispinum* (Deflandre) ; Sarjeant: 488, text-fig. 9d.
1964 *B. parvispinum* (Deflandre) ; Downie & Sarjeant: 94.
1964a *B. parvispinum* (Deflandre) ; Sarjeant, table 3.
1966 *Prolixosphaeridium parvispinum* (Deflandre) ; Davey, Downie, Sarjeant & Williams: 173.
1967a *P. parvispinum* (Deflandre) ; Sarjeant, table 7.

Description. The shell is elongate to oval in shape, bearing short, conical, simple processes in large number. The apical pole is lost in archaeopyle formation. The surface of the shell is densely granular.

Figured specimen. BM(NH) slide V.53956(2). Kimmeridge Clay from 20 ft. above the Ringstead Coral Bed, west of Osmington Mills, Dorset (OM 420).

Dimensions. Figured specimen : shell length (apex lacking) 44 $\mu$, breadth 30 $\mu$ ; process length 3–5 $\mu$. Range (3 English specimens measured) : shell length (apex lacking) 35–44 $\mu$, breadth 15–30 $\mu$ ; (one Scottish specimen measured) : shell length 35 $\mu$, breadth 15 $\mu$ ; process length 4 $\mu$.

Remarks. This species was observed only in Dorset and Scottish assemblages and is here described for the first time from the Kimmeridgian. It has a very wide stratigraphic and geographic range. Deflandre observed it in the Lower Cretaceous (Aptian) assemblages of France (1937), and described as a variety of *Hystrichosphaeridium xanthiopyxides* O. Wetzel. Conrad recorded it from the Upper Cretaceous (Maestrichtian) of Belgium (1941). A similar species was observed in the Lower Cretaceous (Aptian-?Albian) of Australia and New Guinea (Cookson & Eisenack, 1958) ; it was differentiated from *H. xanthipyxides* and created a new species, *H. parvispinum*, whose basionym was *H. xanthiopyxides* var. *parvispinum* Deflandre. Klement transferred this new species to the genus *Baltisphaeridium*. It was recorded for the first time from Ampthill Clay (Oxfordian), England, by Sarjeant (1962). When Davey, Downie, Sarjeant and Williams established the new genus, *Prolixosphaeridium*, the species *parvispinum* was transferred to it on the basis of shape, character of processes and possession of an apical archaeopyle.

## Genus *SYSTEMATOPHORA* Klement, 1960

### *Systematophora areolata* Klement, 1960

(Pl. 8, fig. 6 ; Pl. 11, fig. 10)

1960 *Systematophora areolata* Klement: 62–64, pl. 9, figs. 1–8 ; text-fig. 32.
1961a *S. areolata* Klement ; Evitt: 398, pl. 9, figs. 1, 2.
1964 *S. areolata* Klement ; Downie & Sarjeant: 146.
1964a *S. areolata* Klement ; Sarjeant, table 3.
1967 *S. areolata* Klement ; Dodekova: 23–24, pl. 3, figs. 7, 8.
1967a *S. areolata* Klement ; Sarjeant, table 7.

Description. Shell spherical to ellipsoidal in shape, bearing groups of processes together with single processes. The processes of the groups are placed so as to divide the whole surface into more or less polygonal or circular plate-like areas or fields. These fields are bordered by narrow crests. Solid, distally closed simple or furcate processes rise up from the crest in each field ; they are somewhat flexuous. These processes are not connected at their tips. Some simple, isolate processes are present equatorially between the fields. The surface of the central body is smooth or finely granular. An apical archaeopyle was observed in some specimens.

Figured specimens. BM(NH) slide V.53937(1). Clay from *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Specimen SS 625/7–160. Shale from 60 ft. above the second dolerite sill, Staffin Bay, Isle of Skye.

Dimensions. Range of the English specimens (20 specimens measured) : shell length 32–53 μ, breadth 26–56 μ ; processes length 18–23 μ. French specimens (100 specimens measured) : shell length 30–55 μ, breadth 25–55 μ ; process length 15–25 μ. 10 Scottish specimens measured : shell length 45–60 μ, breadth 40–67 μ, process length 12–25 μ.

Remarks. *S. areolata* was originally described by Klement from the Malm Delta of Germany. It is abundantly present in the basal Kimmeridgian assemblages of England, France and Scotland.

## ***Systematophora orbifera*** Klement, 1960

(Pl. 4, fig. 3)

1960 *Systematophora orbifera* Klement: 66–67, pl. 9, figs. 9–10 ; pl. 10, fig. 7.
1961a *S. orbifera* Klement ; Evitt: 398.
1964 *S. orbifera* Klement ; Downie & Sarjeant: 146.
1964a *S. orbifera* Klement ; Sarjeant, table 3.
1966 *S. orbifera* Klement ; Schulz & Mai, table 1.
1967 *S. orbifera* Klement ; Dodekova: 25–26, pl. 3, fig. 6.
1967b *S. orbifera* Klement ; Sarjeant, table 7.

Description. Subspherical to ovate shell with oriented small fields distributed over the whole shell surface. These circular fields are enclosed by solid, distally closed processes. In each group the processes rise up very close together ; they are interconnected in complex fashion at their tips. Between the fields some simple, isolate, single processes are present, which are placed equatorially.

Shell surface smooth or finely granular. An apical archeopyle is sometimes present.

Figured specimen. BM(NH) slide V.53936(1). Clay from *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Figured specimen : shell length (apex lacking) 62 μ, breadth 50 μ ; length of the processes 25–30 μ. Range of the English specimens (26 specimens measured) : shell length 48–60 μ, (apex lacking) 40–55 μ, breadth 33–55 μ ; process length 25–28 μ. French specimens (43 specimens measured) : shell length 48–62 μ, breadth 45–50 μ, shell length (apex lacking) 45–57 μ ; process length 20–31 μ. 6 Scottish specimens measured : shell length 40–70 μ, breadth 36–55 μ ; process length 12–20 μ.

Remarks. *S. orbifera* was originally described from the Malm Alpha of Germany. It was observed in abundance in all the assemblages from Dorset, Normandy, Boulonnais and Scotland.

This species has a more elongate shell than *S. areolata* and differs from all the other species in the character of its processes.

### *Systematophora* sp.

(Pl. 8, fig. 5)

DESCRIPTION. *Systematophora* having an elongate shell bearing groups of processes. One pole (apical) of the shell is lost in archaeopyle formation, the opposite pole is rounded. The shell wall is composed of two layers, the periphragm forming the processes. The surface of the shell is finely granular.

The processes in the groups are short, their length not more than one fourth of the shell breadth. They are broad-based, foliate and deeply forked at their distal end. There is no connection between the processes on their proximal and distal tips. They rise up separately from each other, showing a polygonal orientation on the periphragm and giving an aspect of small fields. There are four groups on the epitract, four groups on the hypotract and a small group on the antapex ; in each group the number of the processes is between 5 and 7.

FIGURED SPECIMEN. BM(NH) slide V.53962(1). Kimmeridge Clay from Great Ouse River Board Pit, Stretham, Cambridgeshire (SC 444).

DIMENSIONS. Figured specimen : shell length (apex lacking) 35 $\mu$, breadth 28 $\mu$ ; process length 6–8 $\mu$.

REMARKS. A single, well-preserved specimen was observed in the base of Kimmeridge Clay of Stretham. Because of its small fields on the shell, it resembles known species of *Systematophora*, but on the basis of the shape and character of its processes, it differs from all previously described species of the genus. It clearly represents a new species, for fuller knowledge of which further specimens must be awaited.

## Genus ***TAENIOPHORA*** Klement, 1960

### ***Taeniophora iunctispina*** Klement, 1960

(Pl. 9, fig. 5)

1960 *Taeniophora iunctispina* Klement: 68, pl. 10, figs. 1–6.
1964 *T. iunctispina* Klement ; Downie & Sarjeant: 146.
1964a *T. iunctispina* Klement ; Sarjeant, table 3.
1967b *T. iunctispina* Klement ; Sarjeant, table 7.

DESCRIPTION. This chorate cyst is spherical to broadly ovoidal in shape, bearing processes in groups randomly oriented on the surface of the shell. These processes are long, solid, simple or branched near to their distal ends. They are proximally connected by narrow basal ridges, surrounding fields of circular outline. The surface of the shell is finely granular. There is no tabulation, but a patch clear of processes, suggesting a sulcus, is present, defined by the arrangements of the groups of processes. An apical archaeopyle was developed by some of the specimens.

FIGURED SPECIMEN. BM(NH) slide V.52800(3). Shaly clay from *Liostrea delta* Bed of Osmington Mills, Dorset (OM 131).

DIMENSIONS. Figured specimen : shell length (apex lacking) 45 $\mu$, breadth 48 $\mu$ ; process length 22–27 $\mu$. Range of the English specimens (9 specimens measured) : shell length 45–65 $\mu$, breadth 40–50 $\mu$ ; process length 15–26 $\mu$. French specimens

(10 specimens measured) : shell length 45–55 μ, breadth 40–50 μ ; process length 15–24 μ. 3 specimens from the Scottish assemblages were observed and measured : shell length 45–60 μ, breadth 35–50 μ ; process length 15–17 μ .

Remarks. *T. iunctispina* has been recorded from the Upper Jurassic (Malm Alpha) of Germany by Klement (1960). It is observed in the Dorset, Scottish and French assemblages for the first time.

Cyst-Family Uncertain

Genus ***STEPHANELYTRON*** Sarjeant, 1961

***Stephanelytron*** cf. ***scarburghense*** (Sarjeant)

(Pl. 10, fig. 2 ; Pl. 13, fig. 8)

Description. Shell spherical to ovoidal in shape with smooth surface, bearing numerous rows of tubes. These tubes are hollow and distally open. There is a large membraneous corona on one pole, a polygonal opening on the opposite pole.

Figured specimens. BM(NH) slide V.52792(3) and slide OM 131/1-267. Both from the *Liostrea delta* Bed of Osmington Mills, Dorset (OM 131).

Dimensions. Range of the observed specimens : length 36–48 μ, breadth 35–40 μ ; length of tubes 5–6 μ; height of corona 10–12 μ. Measured specimens 6 in number. These are comparable with the holotype dimensions of *S. scarburghense* : overall length 45 μ, breadth 40 μ ; corona 12 μ high and the length of the tubes 5 μ (quoted by Sarjeant, 1961).

Remarks. *S. scarburghense* has been previously recorded from the Oxford Clay of England. The specimens observed are similar to *S. scarburghense* as figured by Sarjeant ; processes appear thinner, however, and for this reason these forms are compared with, rather than placed in, Sarjeant's species. The specimens are few in number and generally badly preserved.

L. E. Stover (personal communication to W. A. S. Sarjeant) has recently demonstrated the dinoflagellate affinity of this genus. His results are not yet published.

Cyst-Family **HYSTRICHOSPHAERACEAE** O. Wetzel, emend. Sarjeant & Downie, 1966

Genus ***HESLERTONIA*** Sarjeant, 1966

***Heslertonia pellucida*** sp. nov.

(Pl. 4, fig. 12 ; Pl. 14, fig. 2 ; Text-fig. 26)

Derivation of the name. Latin, *pellucidus*, transparent, in reference to the thin shell wall.

Diagnosis. *Heslertonia* having a spheroidal to polyhedral shell without an apical horn. Tabulation : 4′, 6″, 6c, 6‴, 1p, 1pv and 1⁗. Borders of the plates characteristically formed by broad winged edges. Cingulum broad and slightly

laevorotatory ; sulcus broad and short, mainly extending on the hypotract. Shell wall transparent and surface smooth. Precingular archaeopyle present, formed by loss of plate 3″.

Holotype. BM(NH) slide V.53620(2). Kimmeridge Clay from 100 ft. above the second dolerite sill, east of Digg, Staffin Bay, Skye (SS 627).

Dimensions. Holotype : shell diameter 30×30 μ ; height of the crests 4–8 μ ; breadth of the cingulum 5–6 μ. Dimensions of the second specimen : shell diameter 28×28 μ ; height of the crests 6–8 μ ; breadth of the cingulum 5–6 μ.

Description. A small proximochorate cyst, characterized by the high crests rising from the plate boundaries. Neither an apical horn nor any appendages are developed.

Four apical and six precingular plates form the epitract. Plate 1′ is elongate ; the other three apical plates are polygonal in shape. Plate 3′ is larger than plates

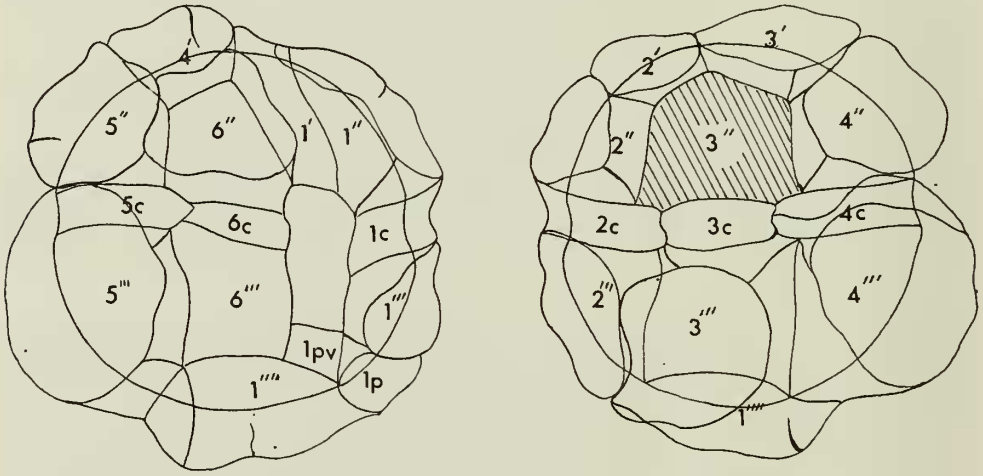


Fig. 26. *Heslertonia pellucida* sp. nov. Holotype, showing the tabulation and the archaeopyle formation. Left, ventral view ; right, dorsal view. ×*c.* 1580.

2′ and 4′, which are almost equal in size. No anterior intercalary plate was observed. The precingular plates are polygonal and more or less uniform in size.

The slightly laevorotatory cingulum is occupied by six cingular plates : plate 1c is smallest, plate 4c is longest of the cingular plates. The ends of the cingulum are widely separated by a broad sulcus.

Six postcingular plates are present. Plate 1″′ is reduced to accommodate the posterior intercalary plate 1p. The other postcingular plates are relatively large. The two posterior intercalary plates are small ; plate 1pv is tetragonal and placed in the posterior prolongation of the sulcus. A single large antapical plate occupies the antapex.

Remarks. The remarkably well preserved, but transparent specimens were observed in the basal Kimmeridgian assemblages (one from Stretham and one from

Staffin Bay). Tabulation is difficult to determine because of the high crests between the plates and the transparent shell wall.

This new species of *Heslertonia* differs from the only previously known species of the genus (*H. heslertonensis*) in the form of its crests and the tabulation. This is the first species of the genus recorded from Jurassic strata. Although only two specimens were found, it was considered that their excellent preservation and clearly distinguishable characters fully justified their differentiation as a second species of this genus.

## Cyst-Family Uncertain

## Genus ***EPIPLOSPHAERA*** Klement, 1960

### ***Epiplosphaera reticulospinosa*** Klement, 1960

(Pl. 1, fig. 4)

1960 *Epiplosphaera reticulospinosa* Klement: 75–76, pl. 8, figs. 10–12.
1964 *E. reticulospinosa* Klement ; Downie & Sarjeant: 112.
1964a *E. reticulospinosa* Klement ; Sarjeant, table 3.
1966 *E. reticulospinosa* Klement ; Schulz & Mai, table 1.
1967b *E. reticulospinosa* Klement ; Sarjeant, table 9.

Description. The spherical or subspherical shell shows a small-meshed reticulation on the surface. The processes arise at the point of junction of the reticulum ; they are simple, hollow, distally closed, bifid or briefly bifurcate. The shell wall is composed of two layers, the endophragm forming the processes. The surface of the shell is smooth. An apical archaeopyle is present.

Figured specimen. BM(NH) slide V.53932(2). Clay from *Liostrea delta* Bed, Villerville, Normandy (VN 184).

Dimensions. Figured specimen : shell length 45 $\mu$, breadth 40 $\mu$ ; process length 8 $\mu$. Range (4 English specimens were measured) : shell length 38–60 $\mu$, breadth 38–65 $\mu$ ; process length 5–12 $\mu$ ; (2 French specimens were measured) : shell length 35–45 $\mu$, breadth 25–40 $\mu$ ; process length 7–8 $\mu$. Klement gave the following dimensions for this species : shell length 52–55 $\mu$, breadth 46–49 $\mu$ ; process length 12–15 $\mu$. The French specimens are thus smaller than English and German specimens. The processes of the German specimens are longer than the basal Kimmeridgian specimens.

Remarks. This species has been recorded from Malm Delta of Germany (Klement, 1960). It was observed in the assemblages from Dorset, Stretham and Normandy in small numbers. It differs from *E. areolata* in that it does not show a regular quadrilateral structure on the shell surface. It also differs from *E. bireticulata* in the absence of a second reticulum superimposed on the first.

Cyst-Family **ENDOSCRINIACEAE** Vozzhennikova, emend. Sarjeant & Downie, 1966

Genus ***ENDOSCRINIUM*** Klement, emend. Vozzhennikova, 1967a

***Endoscrinium*** cf. ***campanula*** (Gocht)

(Pl. 5, figs. 9, 10 ; Text-fig. 27)

Description. A broadly ovate theca with a blunt, broad apical horn. Tabulation : 4′, 6″ 6c, 5″ ′, ?1p, 0″ ″. The crests are moderately high and irregularly perforated ; their distal edges are smooth. The cingulum forms a strong laevorotatory spiral, dividing the theca into two more or less equal parts. The epitract is pyramidal, the hypotract hemispherical. An endoblast, of similar shape to the shell, is present. The well developed sulcus broadens markedly towards the antapex. The surface of the periphragm is granular. A precingular archaeopyle forms by loss of plate 3″.

Figured specimen. BM(NH) slide V.52795(1). Shelly clay from *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

Dimensions. Figured specimen : overall length 90 μ, breadth 85 μ ; endoblast length 76 μ, breadth 70 μ. Range of the English specimens (6 specimens measured) : overall length 75–96 μ, breadth 60–85 μ ; endoblast length 50–78 μ, breadth 48–75 μ. French specimens (12 specimens measured) : overall length 78–105 μ, breadth 68–82 μ ; endoblast length 55–75 μ, breadth 50–75 μ. Only one specimen from the Scottish material was observed and measured : overall length 93 μ, breadth 85 μ ; endoblast length 73 μ, breadth 65 μ.

*E. campanula* holotype dimensions, as quoted by Gocht, are overall length 104 μ, breadth 91 μ. The basal Kimmeridgian specimens from France are of similar size to the holotype, but the Scottish and English specimens are a little smaller.

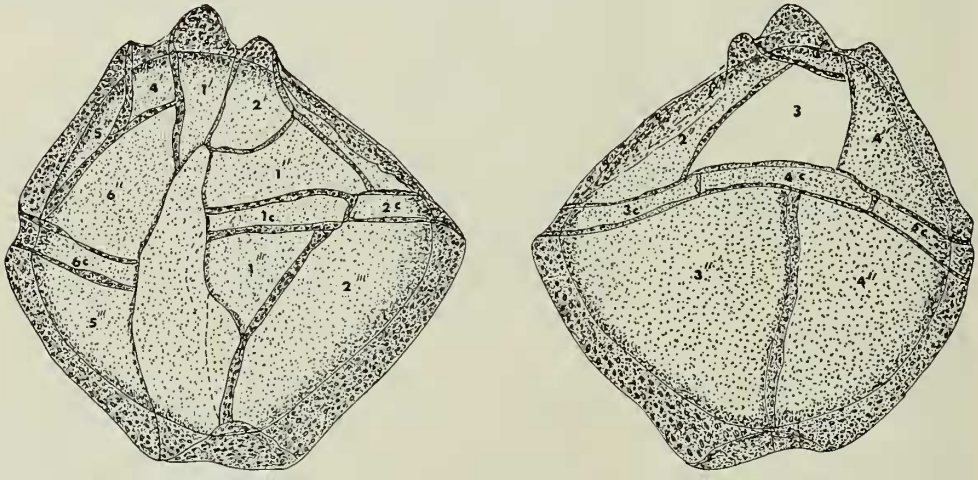


Fig. 27. *Endoscrinium* cf. *campanula* (Gocht). Tabulation and the archaeopyle formation. Left, ventral view ; right, dorsal view. ×*c.* 1280.

Remarks. *E. campanula* has been recorded from the Lower Cretaceous (Lower and Upper Hauterivian) of Germany by Gocht (1959) and Alberti (1961), and also described from the Middle Cretaceous (Upper Albian and Lower Cenomanian) by Cookson and Hughes (1964) ; from Albian, Cenomanian and Turonian of England (Davey, 1966). Vozzhennikova observed it in the Barremian assemblages of Russia.

Similar specimens to this species were observed in the basal Kimmeridgian assemblages from Dorset, Scotland and the Boulonnais. These specimens are comparable with the specimens described as *E. campanula,* in their general morphologic features, but differ in the following few points : the surface of the shell of *E.* cf. *campanula* is granular, its crests perforate and endoblast rounded at the apex, and the apical horn forms from the periphragm only.

### ***Endoscrinium galeritum*** (Deflandre) Vozzhennikova, 1967a

(Pl. 3, figs. 7, 8 ; Pl. 8, fig. 3)

1938a *? Gymnodinium galeritum* Deflandre: 167, pl. 5, figs. 7–9 ; pl. 6, fig. 1 ; text-fig. 1.
1957 *Scriniodinium galeritum* (Deflandre) ; Klement: 110.
1960 *S.* (*Endoscrinium*) *galeritum* (Deflandre) ; Klement: 22–27, pl. 1, figs. 4–12 ; pl. 2, figs. 1–2; text-figs. 4–5.
1961a *S. galeritum* (Deflandre) ; Sarjeant: 98–99, pl. 14, fig. 6.
1962a *S. galeritum* (Deflandre) ; Sarjeant, tables 3, 4.
1962b *S. galeritum* (Deflandre) ; Sarjeant, tables 2, 3.
1964 *S. galeritum* (Deflandre) ; Downie & Sarjeant: 144.
1964 *S. galeritum* (Deflandre) ; Eisenack: 359–760.
1964a *S. galeritum* (Deflandre) ; Sarjeant, table 2.
1966 *S. galeritum* (Deflandre) ; Schulz & Mai, table 1.
1967a *Endoscrinium galeritum* (Deflandre) ; Vozzhennikova: 137, figs. 44a, b.
1967b *E. galeritum* (Deflandre) ; Vozzhennikova: 176, pl. 93, fig. 7, table 2.
1967 *Scriniodinium galeritum* (Deflandre) ; Dodekova: 13–14, pl. 1, figs. 1–5.
1967b *Endoscrinium galeritum* (Deflandre) ; Sarjeant, table 11.
1968 *E. galeritum* (Deflandre) ; Sarjeant: 236, pl. 1, fig. 11, table 2B.

Remarks. This species of *Endoscrinium* is known from the Middle-Upper Jurassic only ; having been described from the Callovian of Normandy (Sarjeant, 1968) ; Oxfordian of France (Calvados) by Deflandre (1938) and England (Dorset and Yorkshire) by Sarjeant (1961, 1962) ; Malm Alpha of Germany (Klement, 1960) and Volgian of Russia (Moscow) by Vozzhennikova (1967). It was observed in the assemblages from Dorset and the Boulonnais ; it is infrequent and badly preserved, the figured specimen being the best one found.

Figured specimens. BM(NH) slide V.52800(4). Shaly clay from *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

Slide RB 219/1–7, from the base of Kimmeridge Clay, *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset.

Dimensions. Range of the English specimens (3 specimens measured) : overall length 78–90 $\mu$, breadth 72–78 $\mu$ ; endoblast length 72–80 $\mu$, breadth 67–75 $\mu$. 2 French specimens were measured : overall length 75–86 $\mu$, breadth 65–75 $\mu$.

## *Endoscrinium luridum* (Deflandre), emend. Vozzhennikova, 1967b

(Pl. 3, fig. 2 ; Text-fig. 28)

1938a *Gymnodinium luridum* Deflandre: 166, pl. 5, figs. 4–6.
1957 *Scriniodinium luridum* (Deflandre); Klement: 109–110.
1958 *Gymnodinium luridum* Deflandre; Cookson & Eisenack: 24, pl. 1, figs. 3, 4.
1960 *Scriniodinium luridum* (Deflandre); Sarjeant, pl. 12, fig. 2.
1960 *Scriniodinium* (*Endoscrinium*) *luridum* (Deflandre); Klement: 20–22, pl. 1, figs. 1–3; text-figs. 2–3.
1962a *S. luridum* (Deflandre); Sargeant: 259–261, pl. 1, fig. 14, tables 3, 4.
1962b *S. luridum* (Deflandre); Sarjeant, pl. 69, fig. 7.
1964 *S. luridum* (Deflandre); Downie & Sarjeant: 144.
1964 *S. luridum* (Deflandre); Eisenack: 767–768.
1964a *S. luridum* (Deflandre); Sarjeant, table 2.
1967 *S. luridum* (Deflandre); Dodekova: 12–13, pl. 1, fig. 3.
1967b *Endoscrinium luridum* (Deflandre); Vozzhennikova: 175.
1967b *E. luridum* (Deflandre); Sarjeant, table 11.
1968 *E. luridum* (Deflandre); Sarjeant, table 2B.

Remarks. This species was recorded from the Upper Jurassic (Oxfordian–Kimmeridgian) of England, France, Germany, Bulgaria and Australia. It is extremely infrequent in assemblages from Dorset, Normandy and the Boulonnais, but quite frequent in the Scottish material.

Figured specimen. BM(NH) slide V.53934(3). Clay from *Liostrea delta* Bed of Villerville, Normandy (VN 184).

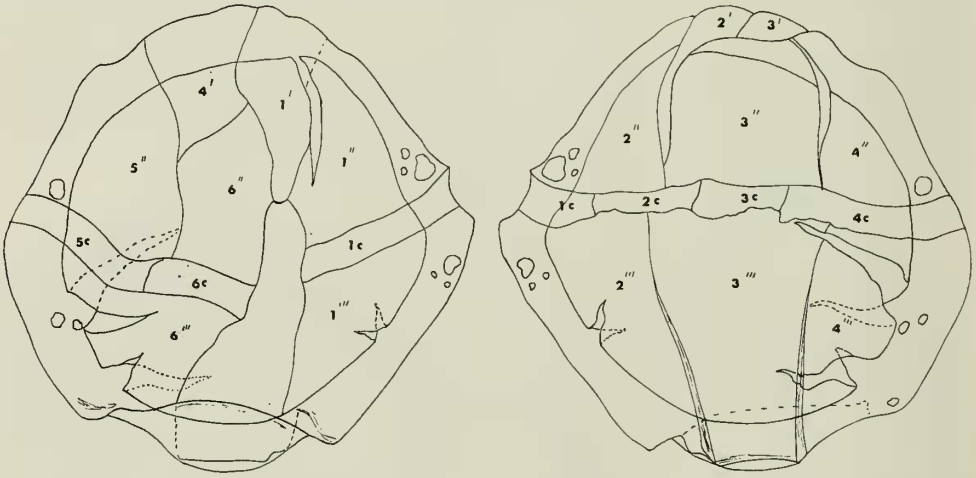


Fig. 28. *Endoscrinium luridum* (Deflandre). Tabulation and the archaeopyle formation (plate 3″ remains attached). Left, ventral view ; right, dorsal view. ×*c.* 1280.

Dimensions. Figured specimen : overall length 92 μ, breadth 68 μ ; endoblast length 76 μ, breadth 55 μ. Other two French specimens overall length 55–90 μ, breadth 52–85 μ ; endoblast length 45–75 μ, breadth 46–70 μ. Range of the English specimens (3 specimens measured) : overall length 90–120 μ, breadth 80–110 μ ;

endoblast length 63–90 μ, breadth 62–85 μ. Scottish specimens (5 specimens measured) : overall length 50–90 μ, breadth 48–90 μ ; endoblast length 45–70 μ, breadth 40–70 μ.

### *Endoscrinium oxfordianum* (Sarjeant) Vozzhennikova, 1967a

(Pl. 5, fig. 6)

1960 *Scriniodinium* sp. Sarjeant: 394, pl. 13, fig. 2.
1962a *Scriniodinium* (?*Endoscrinium*) sp. Sarjeant; Sarjeant: 263, pl. 1, fig. 15.
1962b *Scriniodinium* (?*Endoscrinium*) *oxfordianum* Sarjeant; Sarjeant: 485–486, pl. 69, figs. 13–14; tables 2–3.
1964 *Scriniodinium oxfordianum* Sarjeant; Downie & Sarjeant: 144.
1964 *S.* (?*Endoscrinium*) *oxfordianum* Sarjeant; Eisenack: 769.
1964a *S. oxfordianum* Sarjeant; Sarjeant, table 2.
1967a *Endoscrinium oxfordianum* (Sarjeant); Vozzhennikova: 175.
1967 *E. oxfordianum* (Sarjeant); Sarjeant, table 11.

Remarks. This species was previously recorded from the Oxfordian of England. It is infrequent in the basal Kimmeridgian assemblages and generally the preservation was not good.

Figured specimen. BM(NH) slide V.53933(1). Clay from *Liostrea delta* Bed of Villerville, Normandy (VN 184).

Dimensions. Figured specimen : overall length 80 μ, breadth 68 μ ; endoblast length 63 μ, breadth 60 μ. The other French specimens and the English specimens were not capable of measurement. Range of the Scottish specimens (4 specimens measured) : overall length 60–100 μ, breadth 40–85 μ ; endoblast length 48–75 μ, breadth 32–75 μ.

## Genus ***PSALIGONYAULAX*** Sarjeant, 1969

### ***Psaligonyaulax apaleta*** (Cookson & Eisenack), Sarjeant, 1969

(Pl. 6, fig. 8 ; Text-fig. 29)

1960a *Scriniodinium apatelum* Cookson & Eisenack: 249, pl. 37, figs. 12–13.
1964 *S. apatelum* Cookson & Eisenack; Downie & Sarjeant: 144.
1964 *S. apatelum* Cookson & Eisenack; Eisenack: 747.
1964 *S. apatelum* Cookson & Eisenack; Manum & Cookson: 20, pl. 4, fig. 4.
1964a *S. apatelum* Cookson & Eisenack; Sarjeant, table 2.
1966 *Psaligonyaulax apaleta* (Cookson & Eisenack); Sarjeant, *nomen nudum*: 138
1967b *P. apaleta* (Cookson & Eisenack); Sarjeant, table 11: *nomen nudum*.
1969 *P. apaleta* (Cookson & Eisenack); Sarjeant (in press).

Description. The shell is elongate and bears a small apical horn and a pronounced antapical pericoel ; this is posteriorly narrow, with a spine-like projection at the antapex. The endoblast follows the outline of the shell except at the apex and antapex. There is an apical bulge on the endoblast. There is no tabulation ; the surface of the shell is smooth. A precingular archaeopyle is present, whose plate equivalence is uncertain.

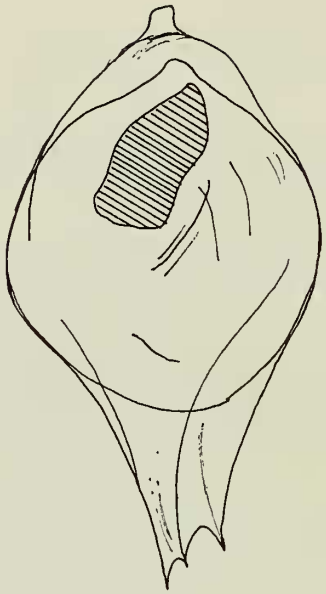

FIG. 29. *Psaligonyaulax apaleta* (Cookson & Eisenack). A specimen from the basal Kimmeridgian of Osmington Mills. ×*c.* 850.

FIGURED SPECIMEN. BM(NH) slide V.52804(1). Clay from 15 ft. above the Ringstead Coral Bed, west of Osmington Mills, Dorset (OM 419).

DIMENSIONS. Figured specimen : overall length 87 μ, breadth 50 μ ; endoblast length 55 μ, breadth 50 μ. Range of the English specimens (9 specimens measured) : overall length 75–105 μ, breadth 35–53 μ ; endoblast length 48–68 μ, breadth 35–53 μ. French specimens (5 specimens measured) : overall length 70–100 μ, breadth 37–60 μ ; endoblast length 45–65 μ, breadth 30–58 μ. Holotype dimensions (as quoted by Cookson and Eisenack) : overall length 120 μ, breadth 58 μ ; endoblast length 80 μ, breadth 58 μ. The Australian specimen is thus larger than the European specimens.

REMARKS. *P. apaleta* has previously been recorded from the Oxfordian to Lower Kimmeridgian of Australia and New Guinea. It was observed in the assemblages from Dorset, Stretham, Normandy and the Boulonnais, but it was not observed in the Scottish material.

### ***Psaligonyaulax*** sp.

(Pl. 3, fig. 6 ; Text-fig. 30)

DESCRIPTION. The elongate shell bears an apical horn which is formed by the periphragm only. There is no determinable tabulation. A large precingular archaeopyle is present on the dorsal side. The surface of the shell is smooth.

FIGURED SPECIMEN. BM(NH) slide V.53956(3). Clay from 20 ft. above the Ringstead Coral Bed, Osmington Mills, Dorset (OM 420).

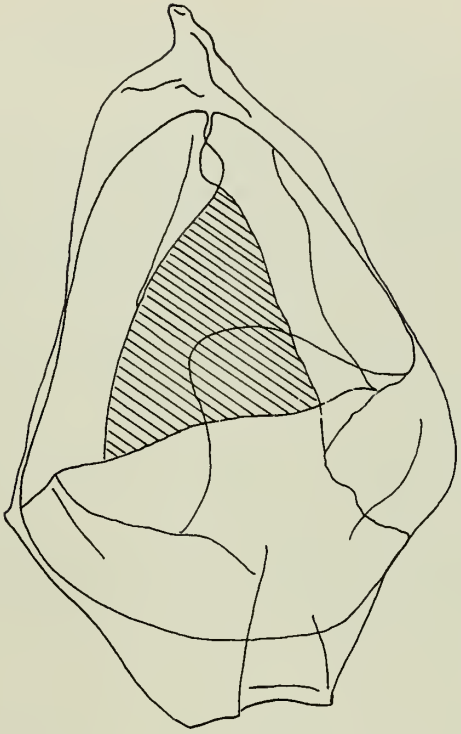

FIG. 30. *Psaligonyaulax* sp. A specimen from Osmington Mills, showing the precingular archaeopyle. ×*c.* 1280.

DIMENSIONS. Figured specimen : overall length 70 μ, breadth 45 μ ; endoblast length 50 μ, breadth 43 μ.

REMARKS. A single specimen was observed, which is closely similar to *P. apaleta* in its general appearance but differs in having a broader and more ovoidal shell. It may be an undescribed species ; for fuller knowledge, further specimens must be awaited.

## Cyst-Family **HEXAGONIFERACEAE** Sarjeant & Downie, 1966

### Genus ***HEXAGONIFERA*** Cookson & Eisenack, 1962

#### ***Hexagonifera*** sp.

(Pl. 1, fig. 12)

DESCRIPTION. A species of *Hexagonifera* which has a thick-walled, broadly ovoidal shell, with 6-sided apical archaeopyle. The surface of the shell is densely granular with occasional tubercles. The shell is completely enclosed in a smooth, delicate

membrane. The circular, equatorial cingulum divides the shell into two equal parts. There is no definite indication of sulcus or of tabulation.

Figured specimen. BM(NH) slide V.53621(1). Shale from 100 ft. above the second dolerite sill, Staffin Bay, Skye (SS 627).

Dimensions. Figured specimen : overall length (apex lacking) 46 $\mu$, breadth 50 $\mu$ ; endoblast length (apex lacking) 40 $\mu$, breadth 42 $\mu$. Range of the English specimens (2 specimens measured) : overall length (apex lacking) 43–50 $\mu$, breadth 48–52 $\mu$ ; endoblast length (apex lacking) 38–40 $\mu$, breadth 42–52 $\mu$. Range of the French specimens (3 specimens measured) : overall length (apex lacking) 42–50 $\mu$, breadth 35–50 $\mu$ ; endoblast length (apex lacking) 38–46 $\mu$, breadth 35–40 $\mu$.

Remarks. Well-preserved specimens are present, relatively infrequently, in assemblages from Dorset, Scotland, Le Havre and the Boulonnais. They are distinguished from the described species of *Hexagonifera* by the presence of a cingulum and the type of sculpture.

These specimens are similar to *Ascodinium verrucosum*, but A. *verrucosum* has one or two antapical horns whereas *Hexagonifera* sp. has a rounded antapex without any projection. Also the cingulum was not mentioned in A. *verrucosum*, whereas it is obvious in *Hexagonifera* sp. Therefore they appear to be different, and this new form is placed in the genus *Hexagonifera* ; possibly it is a new species of the latter genus ; but, before this can be decided, further specimens must be examined.

## Genus ***PARVOCAVATUS*** gen. nov.

Derivation of the name. Latin, *parvus*, little small ; *cavo-atus*, hollow out, with reference to the cavate cyst of microfossil.

Diagnosis. Cavate dinoflagellate cysts, subspherical, ovate to elongate, with the tabulation 4′, 6″, 6c, 6″ ′ and 1″ ″. Cingulum circular, and nearly equatorial. Sulcus long and extending onto epitract and hypotract to equal length. Apical horn present and formed by the periphragm ; this is hollow and has a hole at its tip. Thin periblast surrounding a spheroidal endoblast ; the latter is thick-walled. Archaeopyle apical, the operculum remaining attached. Surface of periphragm smooth, but surface of the endophragm densely tuberculate.

Type species. *Parvocavotus tuberosus* sp. nov. Base of Kimmeridgian, Osmington Mills, Dorset.

Remarks. A group of cavate cysts from the base of the Kimmeridge Clay are characterized by the incipient apical archaeopyle formation and the tabulation. Because of the mode of archaeopyle formation, these microfossils are attributed to Cyst-family Hexagoniferaceae in spite of their possession of tabulation. However, the tabulation, cingulum and sulcus are all poorly marked.

### *Parvocavatus tuberosus* sp. nov.

(Pl. 6, fig. 9 ; Text-fig. 31)

Derivation of the name. Latin, *tuberosus*, full of lumps or protuberances.

Diagnosis. *Parvocavatus* having an ovoidal-polygonal periblast, with a spheroidal endoblast inside. There is a hollow apical horn at the apex, which is formed by the periphragm only and has a hole at its tip. Reflected tabulation : 4′, 6″, 6c, 6″ ′, and 1″ ″. Periphragm thin, endophragm thick, with a densely tuberculate surface. A circular cingulum divides the shell into two nearly equal parts. Apical archaeopyle developed, the operculum typically remaining attached.

Holotype. BM(NH) slide V.53956(4). Kimmeridge Clay from 20 ft. above the Ringstead Coral Bed, Osmington Mills, Dorset (OM 420).

Dimensions. Holotype : overall length 55 $\mu$, breadth 45 $\mu$ ; endoblast diameters 40 × 40 $\mu$. Other English specimens (2 specimens measured) : overall length 52–56 $\mu$, breadth 46–48 $\mu$ ; endoblast diameters 38–40 $\mu$. Range of the French specimens (40 specimens measured) : overall length 50–55 $\mu$, breadth 43–45 $\mu$ ; endoblast diameters 35–45 $\mu$. All the observed specimens were not capable of measurement.

Description. The periblast is ovoidal with a short, blunt apical horn ; the endoblast is spherical ; both periblast and endoblast have a rounded antapex. The epitract and hypotract are nearly equal in size. The sulcus extends between apex and antapex. On the ventral surface there is a split between the apical and precingular plates, which suggests incipient archaeopyle formation. The presence of a hole at the tip of the apical horn is also noteworthy. The precingular plates are

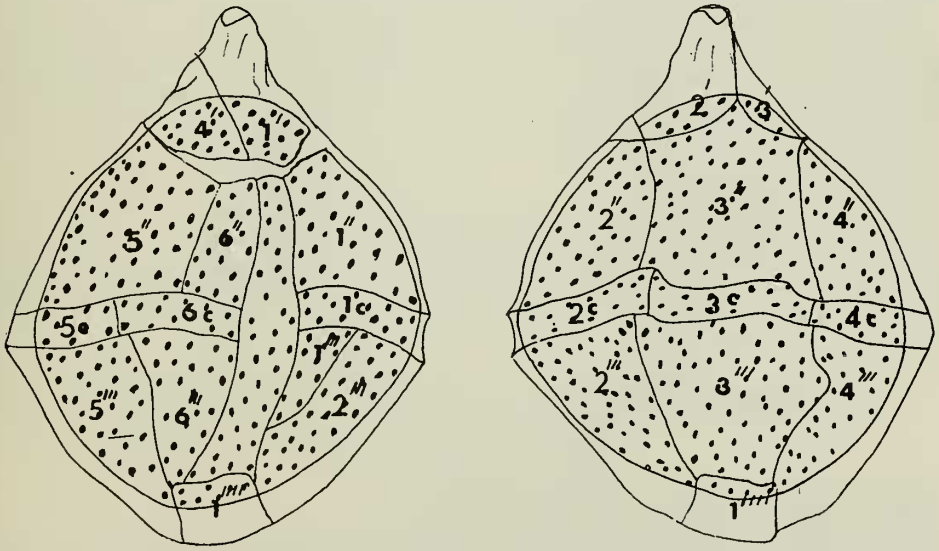

Fig. 31. *Parvocavatus tuberosus* sp. nov. Holotype, showing the tabulation and the archaeopyle formation. Left, ventral view ; right, dorsal view. ×*c.* 1280.

generally large : plate 6″ is smaller than the others. Six postcingular plates are present, plate 1″ ′ small and triangular-shaped. A single antapical plate is present ; it is quite large and convex.

Remarks. *Parvocavatus tuberosus* is similar to *Gardodinium trabeculosum*, but differs in having no processes connecting the two membranes. This new species differs from all previously described species in its combination of the characteristic hole at the tip of the apical horn, archaeopyle formation and tabulation.

*P. tuberosus* is common in the French material, but it is rare in Dorset and Scottish assemblages. Generally the specimens are badly preserved, so that it was difficult to determine the details of the tabulation.

## Cyst-Family **NELSONIELLACEAE** Eisenack, emend. Sarjeant & Downie, 1966

### Genus ***SCRINIODINIUM*** Klement, 1957

#### ***Scriniodinium bicuneatum*** (Deflandre), Sarjeant, 1967a

(Pl. 5, fig. 5)

1938a *Palaeoperidinium bicuneatum* Deflandre: 180, pl. 8, fig. 7.
1957 *P. bicuneatum* Deflandre; Downie: 422, pl. 20, fig. 2.
1964 *P. bicuneatum* Deflandre; Downie & Sarjeant: 137.
1964 *P. bicuneatum* Deflandre; Eisenack: 591–592.
1964a *P. bicuneatum* Deflandre; Sarjeant, table 2.
1967b *P. bicuneatum* Deflandre; Vozzhennikova: 101.
1967a ?*Scriniodinium bicuneatum* (Deflandre); Sarjeant: 248.
1967b *S. bicuneatum* (Deflandre); Sarjeant, table 11.

Remarks. This species has been recorded from the Oxfordian of France (Deflandre, 1938) and Kimmeridgian of England (Downie, 1957) as *Palaeoperidinium bicuneatum* ; Sarjeant (1967) re-attributed to the genus *Scriniodinium* since presence of a tabulation not been confirmed.

Poorly preserved specimens were observed in small numbers in the basal Kimmeridgian assemblages of Dorset.

Figured specimen. BM(NH) slide V.53952(1). Clay from 10 ft. above the Ringstead Coral Bed, west of Osmington Mills, Dorset (OM 418).

Dimensions. Figured specimen : overall length 105 $\mu$, breadth 100 $\mu$. Range : length 88–105 $\mu$, breadth 75–100 $\mu$. 2 specimens were measured.

#### ***Scriniodinium crystallinum*** (Deflandre), emend. Klement, 1957

(Pl. 7, fig. 6 ; Text-fig. 32)

1938a *Gymnodinium crystallinum* Deflandre: 165, pl. 5, figs. 1–3.
1938b *G. crystallinum* Deflandre; Deflandre: 688, fig. 1.
1957 *Scriniodinium crystallinum* (Deflandre); Klement: 109–110, fig. 1.
1958 *G. crystallinum* Deflandre; Cookson & Eisenack, pl. 1, figs. 1–3.
1960 *Scriniodinium crystallinum* (Deflandre); Klement: 18, pl. 1, fig. 1; text-fig. 1.

1961a *S. crystallinum* (Deflandre); Sarjeant: 98, pl. 14, figs. 9–12.
1962a *S. crystallinum* (Deflandre); Sarjeant: 259–261, pl. 2, fig. 2.
1964 *S. crystallinum* (Deflandre); Downie & Sarjeant: 145.
1964 *S. crystallinum* (Deflandre); Eisenack: 753–754.
1964a *S. crystallinum* (Deflandre); Sarjeant, table 2.
1966 *S. crystallinum* (Deflandre); Schulz & Mai, table 1.
1967 *S. crystallinum* (Deflandre); Dodekova: 11–12, pl. 1, figs. 1, 2.
1967b *S. crystallinum* (Deflandre); Sarjeant, table 11.
1968 *S. crystallinum* (Deflandre); Sarjeant, table 2B.

Remarks. This species has been recorded from the Oxfordian of France (Deflandre, 1938a, b) and England (Sarjeant, 1961, 1962) ; Upper Callovian to Lower Oxfordian of Normandy (Sarjeant, 1968) ; Oxfordian to Middle Kimmeridgian of Australia (Cookson & Eisenack, 1957) and Malm Alpha of Germany (Klement, 1957, 1960). It is quite frequent in the basal Kimmeridgian assemblages, but all the specimens encountered are severely damaged, folded or covered by fine debris.

Figured specimen. BM(NH) slide V. 53942(1). Clay from between the Ringstead Coral Bed and Ringstead Waxy Clay, Ringstead Bay, Dorset (RB 219).

Dimensions. Figured specimen : overall length 105 $\mu$, breadth 75 $\mu$ ; endoblast length 95 $\mu$, breadth 70 $\mu$. Range of the English specimens (15 specimens measured) : overall length 90–100 $\mu$, breadth 70–95 $\mu$ ; endoblast length 69–95 $\mu$, breadth 62–90 $\mu$. French specimens (8 specimens measured) : overall length 55–92 $\mu$, breadth 52–95 $\mu$ ; endoblast length 45–76 $\mu$, breadth 46–68 $\mu$. Scottish specimens (5 specimens meas-

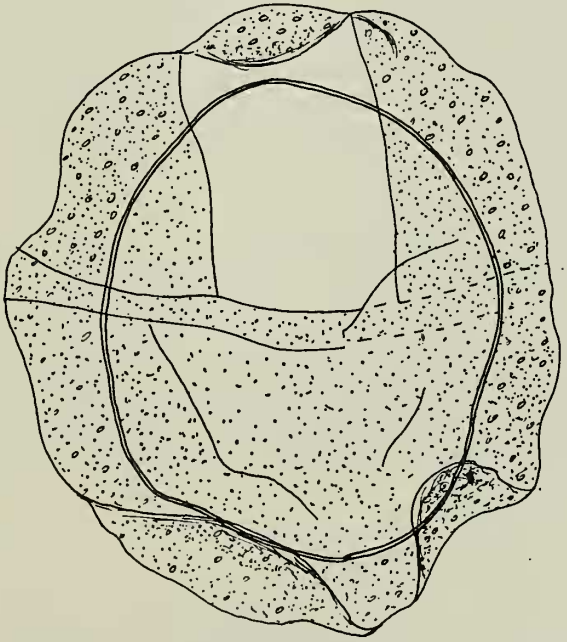

Fig. 32. *Scriniodinium crystallinum* (Deflandre). Dorsal view, showing the precingular archaeopyle. ×*c.* 860.

ured) : overall length 55–105 μ, breadth 50–95 μ ; endoblast length 45–98 μ, breadth 45–75 μ.

Holotype dimensions, as quoted by Deflandre : length 65–92 μ, breadth 58–85 μ. Klement gave the following measurements for German specimens : length 81–127 μ, breadth 72–98 μ. The Kimmeridgian specimens thus accord with those from the European Oxfordian, whereas the Australian specimens are markedly larger.

### *Scriniodinium dictyotum* Cookson & Eisenack, 1960a

1960a *Scriniodinium dictyotum* Cookson & Eisenack: 248–249, pl. 37, figs. 8, 9.
1962a *S. dictyotum* Cookson & Eisenack; Sarjeant: 262, pl. 1, fig. 9, tables 3, 4.
1962b *S. dictyotum* Cookson & Eisenack; Sarjeant, pl. 69, fig. 11.
1964 *S. dictyotum* Cookson & Eisenack, Downie & Sarjeant: 145.
1964 *S. dictyotum* Cookson & Eisenack; Eisenack: 755.
1964a *S. dictyotum* Cookson & Eisenack; Sarjeant, table 2.
1967b *S. dictyotum* Cookson & Eisenack; Sarjeant, table 11.
1968 *S. dictyotum* Cookson & Eisenack; Sarjeant: 236, pl. 1, fig. 7; table 2b.

Remarks. *S. dictyotum* was originally recorded from Upper Jurassic with a stratigraphic range from Upper Callovian to Lower Kimmeridgian.

### *Scriniodinium dictyotum* subsp. *dictyotum* Cookson & Eisenack

Diagnosis. The typical subspecies of *Scriniodinium dictyotum*, with shell flat, oval, divided by a distinct and relatively broad girdle into an epitheca and hypotheca of approximately equal size ; epitheca prolonged into a broadly based, short, blunt apical projection. Capsule oval with a short apical prominence. The wall of the capsule bears numerous thin perpendicular ledges which form a small-meshed supporting reticulum for the thin outer membrane. The meshes of the reticulum vary considerably in size and reach the girdle. [Diagnosis as given, for the type material, by Cookson and Eisenack (1960).]

Holotype. *Scriniodinium dictyotum* Cookson & Eisenack, Melbourne Nat. Mus. Victoria, P 17768. Probably Tithonian, west of Australia.

Remarks. The specimens encountered from the basal Kimmeridgian of Dorset and Le Havre show variation in the character of their apical structure. It is considered necessary, therefore, that the species be subdivided into a number of subspecies, to differentiate these new forms from the specimens within the range of the typical *S. dictyotum* Cookson & Eisenack. The latter forms are redesignated as *S. dictyotum* subsp. *dictyotum*.

### *Scriniodinium dictyotum* subsp. *osmingtonensis* nov.

(Pl. 1, fig. 3 ; Pl. 8, fig. 12)

Derivation of the name. Named after the type locality, Osmington Mills, Dorset.

DIAGNOSIS. *Scriniodinium dictyotum* without any prominence at the apex.

HOLOTYPE. BM(NH) slide V.52797(1). Shaly clay from *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

DIMENSIONS. Holotype : overall length 90 μ, breadth 82 μ ; endoblast length 80 μ, breadth 70 μ. Range of the other specimens (6 specimens measured) : overall length 75–90 μ, breadth 75–82 μ.

DESCRIPTION. The shell is broadly ovate with an endoblast. There is no apical horn. Periblast irregularly reticulate. The cingulum is circular and equatorial. A large precingular archaeopyle is present on the dorsal side. 9 specimens were observed in the materials from Dorset with these structures.

### ***Scriniodinium dictyotum*** subsp. ***papillatum*** nov.

(Pl. 9, fig. 11)

DERIVATION OF THE NAME. Latin, *papilla* teat, nipple, bud ; with reference to the apical projection shape.

DIAGNOSIS. *Scriniodinium dictyotum* characterized by its blunt, mamelon-shaped apical prominence. The endophragm has the same shape as the periphragm.

HOLOTYPE. BM(NH) slide V.53940(1). Clay from 20 ft. above the Ringstead Coral Bed, west of Osmington Mills, Dorset (OM 420).

DIMENSIONS. Holotype : overall length 88 μ, breadth 70 μ. Range (2 specimens measured) : overall length 86–90 μ, breadth 65–85 μ.

DESCRIPTION. The shell is broadly ovoidal in shape, terminating in a mamelon form. The surface of the periphragm is irregularly reticulate.

### ***Scriniodinium dictyotum*** subsp. ***pyrum*** nov.

(Pl. 13, figs. 1, 2 ; Pl. 10, fig. 1 ; Text-fig. 33 a, b)

DERIVATION OF THE NAME. Latin, *pyrum* pear, with reference to the pear-shape of the shell.

DIAGNOSIS. *Scriniodinium dictyotum* with shell elongate, roughly pear-shaped, with a strong apical horn and rounded antapex. The endophragm follows the periphragm except at the apex. The apical prominence of the endoblast is shorter and terminates in a mamelon form. Reflected tabulation : 5′, 6″, 6c, 6″′, 1p and 1″″. A circular cingulum divides the theca into two unequal parts, with epitract longer than the hypotract. Sulcus approximately sigmoidal. A precingular archaeopyle is present.

HOLOTYPE. BM(NH) slide V.53949(2). Clay from *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset (RB 219).

DIMENSIONS. Holotype : overall length 108 μ, breadth 74 μ ; horn length 20 μ. Range of the English specimens (5 specimens measured) : overall length 108–125 μ,

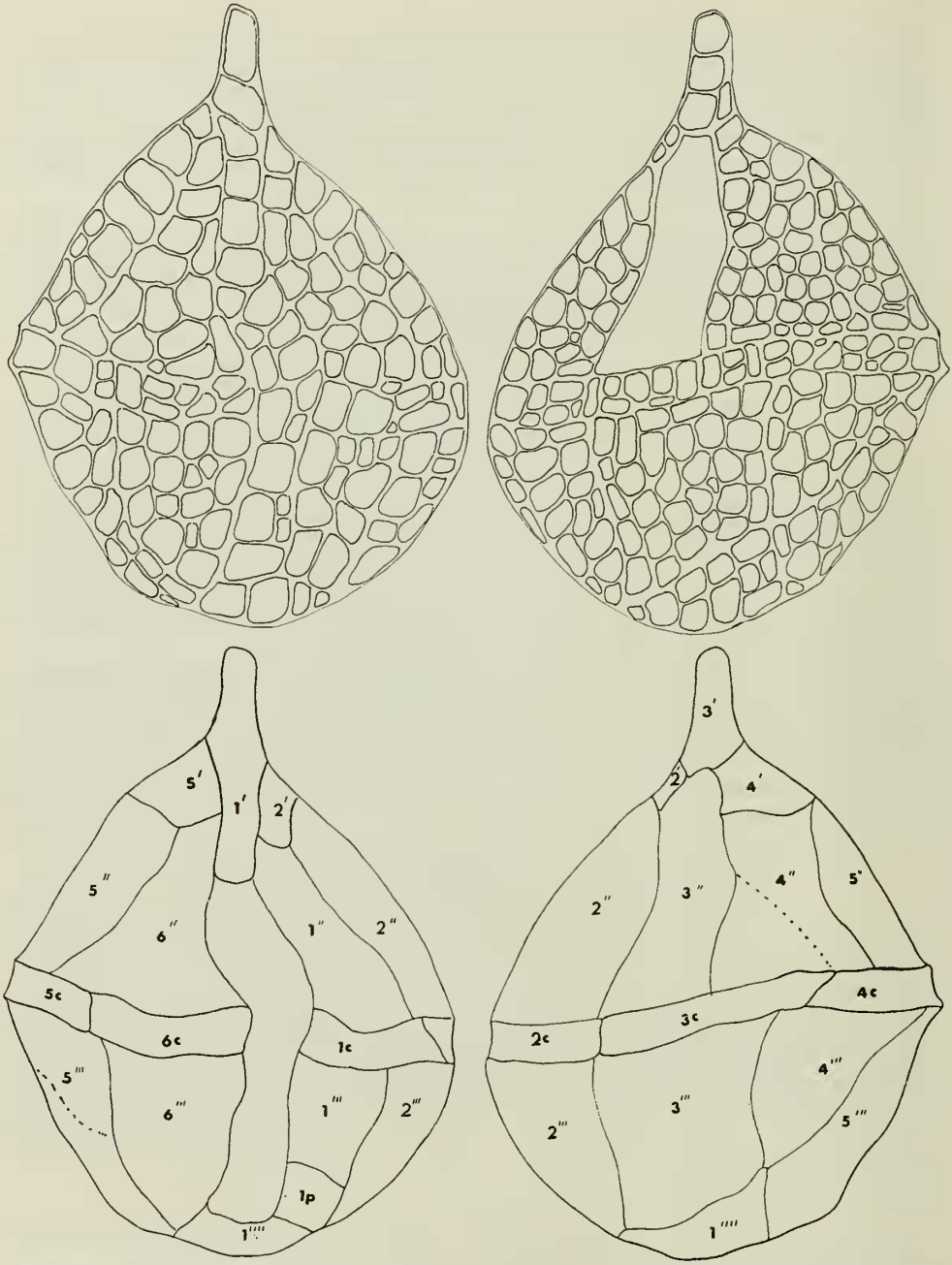


FIG. 33. *Scriniodinium dictyotum* subsp. *pyrum* nov. A. Holotype, showing the general appearance and the archaeopyle. Left, ventral view ; right, dorsal view. ×*c.* 1280. B. Reconstruction of original tabulation from the pattern of reticulation of the cyst. ×*c.* 1280.

breadth 74–90 μ ; horn length 20–30 μ. Dimensions of the French specimen : overall length 106 μ, breadth 70 μ ; horn length 14 μ.

Description. The rather large shell has a strong apical horn. The reflected tabulation is based on the alignment of some field boundaries ; along the boundaries of the plates, the series of alveoli are better developed and so reflect the tabulation. Apical plate 1′ is long and forms the horn, together with plate 3′. Plate 2′ is the smallest of the apical plates ; plates 4′ and 5′ are rather large. The precingular plates are more or less uniform in size. Plate 3″ is lost in archaeopyle formation.

The cingulum is moderately wide and occupied by six plates. The sulcus extends between the apex and the antapex, in moderate breadth and approximately sigmoidal in shape.

The postcingular plates are likewise large, plate 1″ ′ being reduced to accommodate the single posterior intercalary plate 1p. The antapex is occupied by a single, quite large plate.

### *Scriniodinium* cf. *galeatum* (Cookson & Eisenack)

(Pl. 6, fig. 2)

Description. The elongate periblast contains a spherical endoblast and is characterized by well-developed apical and antapical pericoels. A small hollow apical horn is present on the periblast. A narrow helicoid cingulum divides the shell into two unequal parts, with the hypotract longer than the epitract. There is no tabulation and no sign of archaeopyle formation. The endophragm is thick, the periphragm thin, both of them have a smooth surface.

Figured specimen. BM(NH) slide V.53967(1). Calcaires de Moulin Wibert, Cap de La Crèche, Boulonnais (CC 448).

Dimensions. Figured specimen : overall length 75 μ, breadth 45 μ ; endoblast diameters 45 × 45 μ. The second specimen was not capable of measurement because of the preservation.

Remarks. *S. galeatum* has been recorded from the Cenomanian of Australia (Cookson & Eisenack, 1960). Two specimens only were observed from the Boulonnais assemblages ; they are closely similar to *S. galeatum*, but their epitract is broader and shorter than that of the Australian holotype. The cingulum, moreover, is helicoid, not circular as described by Cookson and Eisenack. For these reasons, they are compared with, rather than attributed to, *S. galeatum*.

### *Scriniodinium playfordi* Cookson & Eisenack, 1960a

(Pl. 12, fig. 3)

1958 *Gymnodinium crystallinum* Deflandre; Cookson & Eisenack: 22, pl. 1, fig. 2.
1960a *Scriniodinium playfordi* Cookson & Eisenack: 248–249, pl. 37, fig. 6.
1964 *S. playfordi* Cookson & Eisenack; Downie & Sarjeant: 145.
1964 *S. playfordi* Cookson & Eisenack; Eisenack: 771.

1964a *S. playfordi* Cookson & Eisenack; Sarjeant, table 2.
1967a *S. playfordi* Cookson & Eisenack; Sarjeant, table 11.

Description. The periblast is ovate in shape, with an apical horn ; the endoblast slightly terminates in a mamelon form. There is no tabulation ; but a cingulum is present, nearly circular and equatorial. A precingular archaeopyle is developed by the loss of one plate on the dorsal side. The surface of the periphragm and the endophragm are smooth.

Figured specimen. BM(NH) slide V.53955(1). Clay from 15 ft. above the Ringstead Coral Bed, west of Osmington Mills, Dorset (OM 419).

Dimensions. Figured specimen : overall length 80 $\mu$, breadth 60 $\mu$ ; endoblast length 65 $\mu$, breadth 52 $\mu$, horn length 8 $\mu$. Range of the French specimens (5 specimens measured) : overall length 55–110 $\mu$, breadth 40–90 $\mu$ ; endoblast length 42–90 $\mu$, breadth 40–85 $\mu$.

When compared with the holotype dimensions, as quoted by Cookson and Eisenack (length 166 $\mu$, breadth 147 $\mu$), the European specimens are found to be smaller than the Australian specimens.

Remarks. *Scriniodinium playfordi* has been recorded from the Oxfordian to the Lower Kimmeridgian of Australia and New Guinea (Cookson & Eisenack, 1958). It is infrequently present in the assemblages from Dorset, Le Havre and the Boulonnais. All the specimens observed, were badly preserved.

## Cyst-Family **NETRELYTRACEAE** Sarjeant & Downie, 1966

### Genus ***NETRELYTRON*** Sarjeant, 1961

#### ***Netrelytron parum*** sp. nov.

(Pl. 5, fig. 4 ; Pl. 9, fig. 4)

Derivation of the name. Latin, *par*, a pair, named because of the observation of two shells inside the same organic debris mass.

Diagnosis. *Netrelytron* having a broadly ovoidal periblast, tapering to form a strong apical horn at the apex and a blunt, short mamelon at the antapex. Apical and antapical projections are formed by the periphragm only. Endoblast spheroidal, thin-walled and often hard to distinguish. The surfaces of the endophragm and periphragm are smooth or very finely granular.

Holotype. BM(NH) slide V.52801(2). Shelly clay from the *Liostrea delta* Bed, west of Osmington Mills, Dorset (OM 131).

Dimensions. Holotype : length of the periblast 85 $\mu$, breadth 60 $\mu$ ; apical horn length 16 $\mu$, antapical horn length 6 $\mu$. Range of the English specimens (11 specimens measured) : overall length 60–85 $\mu$, breadth 35–60 $\mu$ ; apical horn length 10–16 $\mu$, antapical horn length 3–6 $\mu$. French specimens (10 specimens measured) : overall length 62–80 $\mu$, breadth 35–60 $\mu$ ; horn length 10–12 $\mu$, antapical horn length 3–5 $\mu$.

Description. The shell is consistently enclosed in a cloak of organic matter. The

periblast is ovoidal in shape, with a spherical endoblast. At the apex of the periblast, a strong apical horn is present, but the antapex is only slightly projecting. Both projections are formed by the periphragm only. Neither tabulation nor an archaeopyle was observed in any of the specimens. Although it is usual to find only a single body enclosed in each organic debris mass, two shells, apex to antapex, inside the same organic debris mass were observed in one instance (pl. 5, fig. 4).

Remarks. This new species is common in the assemblages from Dorset, Normandy and the Boulonnais, but rare in the Le Havre and Stretham material. It is easily distinguishable from the only previously described species of the genus, *N. stegastum*, in its much less-marked antapical horn and more broadly elongate shape.

### *Netrelytron stegastum* Sarjeant, 1961

(Pl. 8, fig. 9 ; Pl. 11, fig. 7)

1961 *Netrelytron stegastum* Sarjeant: 114–115, pl. 15, fig. 15; text-figure 14.
1962b *N. stegastum* Sarjeant; Sarjeant: 494–495, pl. 70, fig. 18, tables 2, 3.
1964 *N. stegastum* Sarjeant; Downie & Sarjeant: 135.
1964a *N. stegastum* Sarjeant; Sarjeant, table 4.
1967a *N. stegastum* Sarjeant; Sarjeant, table 13.

Description. This cavate cyst is spindle-shaped, with apical and antapical horns. There is an endoblast of ovoidal shape. The surface is granular. It was consistently observed with a mass of organic matter surrounding the shell. Neither tabulation nor an archaeopyle was observed.

Figured specimens. BM(NH) slide V.52796(2) and OM 131/14-225. Both from the same locality, shaly clay from the basal Kimmeridge Clay, *Liostrea delta* Bed, Osmington Mills, Dorset (OM 131).

Dimensions. Range of the English specimens (5 specimens measured) : length 89–90 $\mu$, breadth 40–58 $\mu$, horn length 12–16 $\mu$. Range of the French specimens (4 specimens measured) : length 80–88 $\mu$, breadth 57–62 $\mu$, horn length 13–15 $\mu$. Holotype dimensions, as mentioned by Sarjeant (length 125 $\mu$, breadth 55 $\mu$), are larger than the Kimmeridge specimens.

Remarks. This species has been previously recorded from the Lower Oxfordian of England (Sarjeant, 1961). It is infrequently present in the basal Kimmeridgian assemblages from Dorset, Normandy and Le Havre.

## INCERTAE SEDIS

GROUP *ACRITARCHA* Evitt, 1963

SUBGROUP *ACANTHOMORPHITAE* Downie, Evitt & Sarjeant, 1963

Genus ***BALTISPHAERIDIUM*** Eisenack, emend. Downie & Sarjeant, 1963

***Baltisphaeridium inusitatum*** Klement, 1960

(Pl. 13, fig. 5)

1960 *Baltisphaeridium inusitatum* Klement: 60–61, pl. 7, fig. 9.
1964 *B. inusitatum* Klement; Downie & Sarjeant: 91.
1964a *B. inusitatum* Klement; Sarjeant, table 3.

REMARKS. This species has been recorded from the Upper Jurassic (Malm Gamma) of Germany. It is very rare in the basal Kimmeridgian (two specimens from Dorset and one from Normandy were observed).

FIGURED SPECIMEN. BM(NH) slide V.53932(2). Clay from the *Liostrea delta* Bed, Villerville, Normandy (VN 184).

DIMENSIONS. Figured specimen : length 45 $\mu$, breadth 35 $\mu$, process length 28–30 $\mu$. Range of observed English specimens (2 specimens measured) : shell length 40–43 $\mu$, breadth 35–38 $\mu$, process length 23–28 $\mu$.

Genus ***MICRHYSTRIDIUM*** Deflandre, emend. Sarjeant, 1966

***Micrhystridium fragile*** Deflandre, 1947

(Pl. 8, fig. 8 ; Pl. 12, fig. 4)

1947 *Micrhystridium fragile* Deflandre, 8, text-figs. 13–18.
1947 *M. fragile* Deflandre; Valensi, fig. 7.
1953 *M. fragile* Deflandre; Valensi: 41–43, pl. 5, figs. 1–4 & 17–19; pl. 14, figs. 1, 2.
1955 *M. fragile* Deflandre; Valensi, pl. 2, fig. 14.
1959b *M. fragile* Deflandre; Sarjeant: 340, text-figs. 7a–d.
1960 *M. fragile* Deflandre; Sarjeant, pl. 12, fig. 3; pl. 13, figs. 9–14.
1961a *M. fragile* Deflandre; Sarjeant: 105–106, pl. 13, figs. 3, 4; tables 3, 4.
1962a *M. fragile* Deflandre; Sarjeant, tables 2, 3.
1962b *M. fragile* Deflandre; Sarjeant, fig. 8; tables 3, 4.
1963 *M. fragile* Deflandre; Sarjeant, pl. 70, fig. 6.
1963 *M. fragile* Deflandre; Wall & Downie: 774.
1964 *M. fragile* Deflandre; Downie & Sarjeant: 131.
1964 *M. fragile* Deflandre; Takahashi: 205–206, pl. 31, figs. 8–10.
1964a *M. fragile* Deflandre; Sarjeant, table 4.
1965 *M. fragile* Deflandre; Sarjeant: 177, pl. 1, fig. 6.
1965 *M. fragile* Deflandre; Deflandre & Deflandre: fiches 2227–2243.
1966 *M. fragile* Deflandre; Medd: 352, pl. 59, figs. 1, 2.
1967c *M. fragile* Deflandre; Sarjeant, pl. 1, fig. 7; text-fig. 1 h.
1968 *M. fragile* Deflandre; Sarjeant, pl. 1, fig. 5; table 2A.

DESCRIPTION. The spherical to subspherical shell is smooth and thin-walled, bearing 10–18 processes. The processes are strong, straight or curved, hollow,

conical and distally closed. In some of the specimens, opening of shell by splitting was observed.

FIGURED SPECIMENS. BM(NH) slide V.53961(2). Clay from Great Ouse River Board Pit, Stretham, Cambridgeshire (SC 444).

BM(NH) slide V.53948(4). Clay from *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset (RB 219).

DIMENSIONS. Range of the English specimens : shell diameter 14–18 $\mu$, process length 10–16 $\mu$ ; French specimens : shell diameter 12–18 $\mu$, process length 10–15 $\mu$ ; Scottish specimens : shell diameter 8–18 $\mu$, process length 7–15 $\mu$. 25 English, 23 French and 5 Scottish specimens were measured. Holotype diameters 10·5 $\mu$, process length 8–10 $\mu$ (as quoted by Deflandre). Sarjeant gives the mean diameters of the shells from Normandy as 15, 69 $\mu$ (1965). On the basis of these measurements, the Callovian and the basal Kimmeridgian specimens have similar shell diameters.

REMARKS. *M. fragile* has been recorded from the Bajocian and Bathonian of France (Deflandre, 1947 ; Valensi, 1953). Middle Jurassic (Cornbrash) and Upper Jurassic (Oxfordian) of England and France by Sarjeant. Takahashi recorded from Oligocene of Japan (1964) and Medd from Lower Triassic of Western Australia (1966). It is common in English, French and Scottish basal Kimmeridgian materials.

## ***Micrhystridium inconspicuum*** (Deflandre), Deflandre 1937

(Pl. 1, fig. 8 ; Pl. 8, fig. 11 ; Pl. 11, fig. 6)

1935 *Hystrichosphaera inconspicua* Deflandre: 233, pl. 9, figs. 11–12.
1937 *Micrhystridium inconspicuum* (Deflandre); Deflandre: 32, pl. 12, figs. 11–13.
1947 *M. inconspicuum* (Deflandre); Valensi: 817, text-fig. 8.
1947 *M. inconspicuum* (Deflandre); Deflandre: 6, text-figs. 7–12.
1952 *M. inconspicuum* (Deflandre); Deflandre, text-figs. 26–29.
1953 *M. inconspicuum* (Deflandre); Valensi, pl. 2, fig. 10; pl. 7, figs. 14, 15, 20, 23, 26; pl. 8, figs. 1–5, 7–10, 14, 15, 17–20, 23–29, pl. 14, figs. 8–11.
1959b *M. inconspicuum* (Deflandre); Sarjeant: 340, text-fig. 7b.
1960 *M. inconspicuum* (Deflandre); Sarjeant: 398, pl. 14, fig. 18; text-fig. 1f.
1961 *M. inconspicuum* (Deflandre); Brosius & Bitterli: 40, pl. 2, figs. 17–18; text-fig. 8; table 3.
1961a *M. inconspicuum* (Deflandre); Sarjeant: 105, pl. 13, fig. 5; text-fig. 8f, g; tables 3, 4.
1962a *M. inconspicuum* (Deflandre); Sarjeant, pl. 2, fig. 13; text-fig. 8b.
1963 *M. inconspicuum* (Deflandre); Chornaya: 284, pl. 7, fig. 13.
1963 *M. inconspicuum* (Deflandre); Downie & Sarjeant: 92.
1964 *M. inconspicuum* (Deflandre); Spode: 365, pl. 38, fig. j, text-fig. 2j.
1964 *M. inconspicuum* (Deflandre); Downie & Sarjeant: 131.
1964a *M. inconspicuum* (Deflandre); Sarjeant, table 4.
1964 *M. inconspicuum* (Deflandre); Gocht: 124, text-fig. 44.
1965 *M. inconspicuum* (Deflandre); Sarjeant: 177, pl. 1, fig. 4; table 1.
1965 *M. inconspicuum* (Deflandre); Staplin, Jansonius & Pocock: 180.
1965 *M. inconspicuum* (Deflandre); Deflandre & Deflandre: fiches 2251–2273.
1967c *M. inconspicuum* (Deflandre); Sarjeant: 202–203, pl. 1, fig. 2; text-fig. 1D.
1968 *M. inconspicuum* (Deflandre); Sarjeant, pl. 2, fig. 12; table 2A.

DESCRIPTION. The spherical globular shell has a smooth surface from which arise

simple, solid, distally closed processes, about 20–30 in number. There is no regularly formed opening on the surface.

FIGURED SPECIMENS. BM(NH) slide V.53953(1). Clay from 10 ft. above the Ringstead Coral Bed, Osmington Mills, Dorset (OM 418).

BM(NH) slide V.53939(2) and CH 185/10-208, both from Exogyra Marls *c.* 1 m. above the upper Hard Band, Cap de La Hève, Le Havre (CH 185).

DIMENSIONS. French specimens (10 specimens measured) : diameters 10–11 $\mu$, process length 3–5 $\mu$. English specimens (12 specimens measured) : diameters 10–10·5 $\mu$, process length 4·5 $\mu$. Scottish specimens (2 specimens measured) : diameters 8 $\mu$, process length 3 $\mu$.

REMARKS. This species has been recorded from the Middle Jurassic of France (Valensi, 1953 ; Sarjeant, 1962), the Cornbrash of England (Sarjeant, 1959) and the Cretaceous of France (Deflandre, 1935).

### *Micrhystridium sydus* Valensi, 1953

(Pl. 8, fig. 10 ; Pl. 13, figs. 3, 4)

1953 *Micrhystridium sydus* Valensi: 59–60, pl. 8, fig. 40; pl. 9, figs. 3, 5, 11, 17, 23, 24.
1962b *M. sydus* Valensi; Sarjeant, tables 2, 3.
1964 *M. sydus* Valensi; Downie & Sarjeant: 133.
1964a *M. sydus* Valensi; Sarjeant, table 4.
1965 *M. sydus* Valensi; Sarjeant: 178–179, pl. 1, fig. 6.
1965 *M. sydus* Valensi; Deflandre & Deflandre, fiches 2414–2417.
1967c *M. sydus* Valensi; Sarjeant: 201–208.
1968 *M. sydus* Valensi; Sarjeant, table 2A.

DESCRIPTION. The spherical to subpolygonal shell bears 12–14 broad-based, conical processes. These processes are hollow, distally closed ; their cavity connects to the shell cavity. The central body surface is smooth. No opening was observed.

FIGURED SPECIMENS. BM(NH) slide V.53976(1). Shale from 80 ft. above the second dolerite sill, Staffin Bay, Skye (SS 626).

Slide 218/16-324, clay from between Ringstead Waxy Clay and Ringstead Coral Bed, Ringstead Bay, Dorset (RB 218).

DIMENSIONS. English specimens shell diameter 10 $\mu$, process length 7 $\mu$. Range of the Scottish specimens : shell diameters 20–20 $\mu$, process length 7–12 $\mu$ ; French specimens : shell diameters 10–12 $\mu$, process length 5–7 $\mu$. 1 English, 3 Scottish and 4 French specimens were measured.

REMARKS. This species was first recorded from the Bathonian of France (Valensi, 1953) ; subsequently Sarjeant observed it in the Upper Jurassic material of England (1962, 1965) and France (1967). It is rare in the basal Kimmeridgian assemblages of France and Scotland, but abundant in English assemblages.

Sarjeant discussed whether *M. sydus* should be placed in the genus *Veryhachium*, since its spine cavity is connected to the shell interior (Sarjeant, 1965) ; however, *M. sydus* has processes in greater number than is typical for *Veryhachium* and also the processes are shorter than is usual for *Veryhachium*.

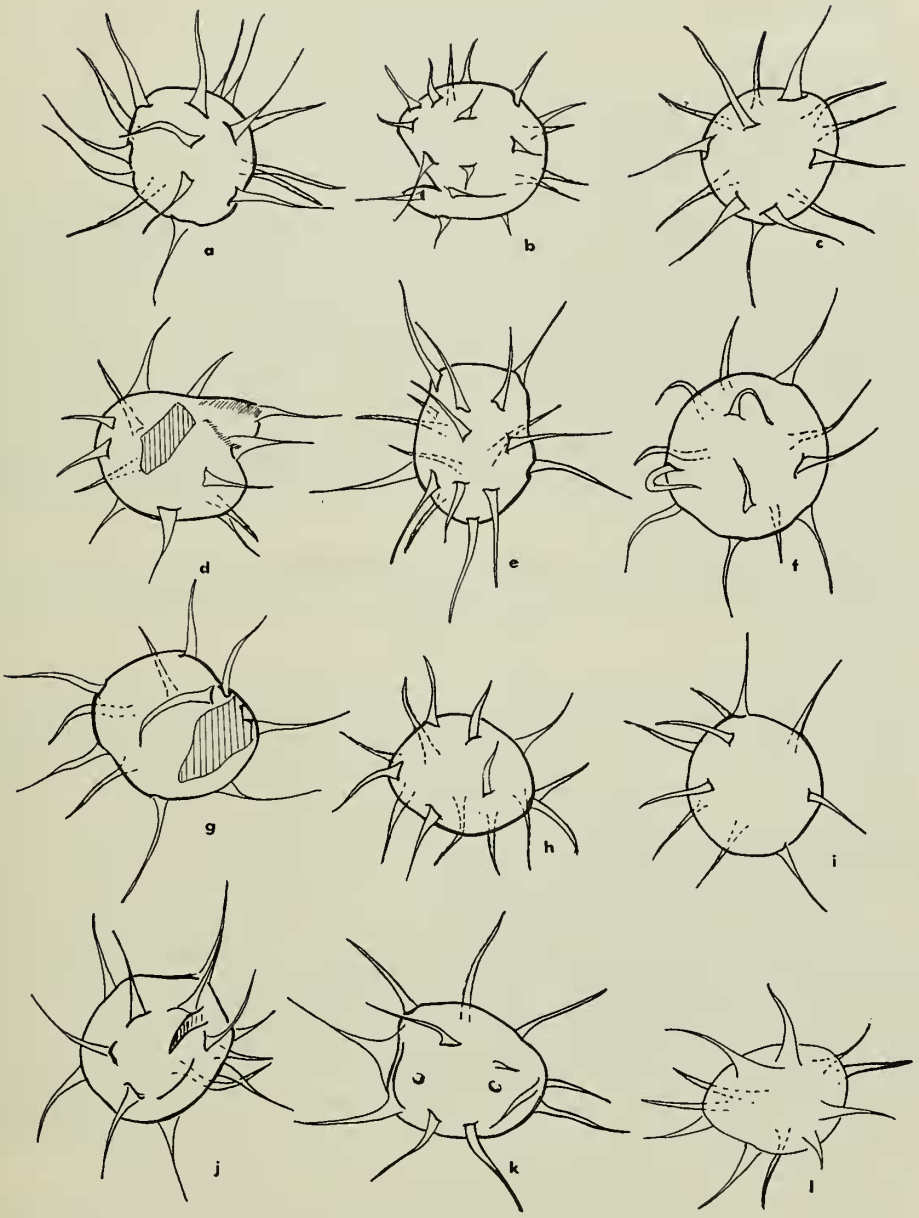


FIG. 34 a–l. *Solisphaeridium stimuliferum* (Deflandre). Specimens from Ringstead Bay Kimmeridge Clay. ×*c.* 1280.

Genus ***SOLISPHAERIDIUM*** Staplin Jansonius & Pocock, emend. Sarjeant, 1968

***Solisphaeridium brevispinosum*** (Sarjeant) emend. Sarjeant, 1968

(Pl. 2, fig. 7)

1961a *Baltisphaeridium ehrenbergi* var. *brevispinosum* Sarjeant: 103, pl. 15, fig. 18; text-fig. 8a.
1964 *B. ehrenbergi* var. *brevispinosum* Sarjeant; Downie & Sarjeant: 90.
1964a *B. ehrenbergi* var. *brevispinosum* Sarjeant; Sarjeant, table 3.
1968 *Solisphaeridium brevispinosum* (Sarjeant); Sarjeant: 223–224, pl. 1, figs. 3–9.

Description. The spherical shell bears simple processes. The shell surface is smooth and thin-walled. The processes are conical with sharply-pointed tips, hollow, straight or curved ; fifty or more in number. The spine cavity is directly connected with the shell interior. No regularly formed opening was observed ; but an opening by splitting was observed in some of the shells.

Figured specimen. BM(NH) slide V.53957(1). Clay from 20 ft. above the Ringstead Coral bed, west of Osmington Mills, Dorset (OM 420).

Dimensions. Figured specimen : diameters 35 $\mu$, length of the processes 15 $\mu$. Other English specimens : diameters 25–30 $\mu$, process length 8–12 $\mu$. 3 English specimens were measured. The French specimen was not capable of measurement, because of poor preservation.

Remarks. *S. brevispinosum* has been recorded from the Oxfordian of England and the Upper Callovian-Lower Oxfordian of Normandy. It is rare in the basal Kimmeridgian.

***Solisphaeridium stimuliferum*** (Deflandre) emend. Staplin, Jansonius & Pocock, 1965

(Pl. 13, fig. 6 ; Text-fig. 34 a–l)

1938a *Hystrichosphaeridium stimuliferum* Deflandre: 162, pl. 1, fig. 10.
1947 *H. stimuliferum* Deflandre; Deflandre, fig. 4.
1952 *H. stimuliferum* Deflandre; Deflandre, fig. 8.
1953 *H. stimuliferum* Deflandre; Valensi, pl. 4, figs. 13, 15, 16.
1960 *Baltisphaeridium stimuliferum* (Deflandre); Sarjeant: 397, pl. 12, fig. 9, text-fig 1j.
1961a *B. stimuliferum* (Deflandre); Sarjeant: 100.
1962 *B. stimuliferum* (Deflandre); Sarjeant, pl. 15, fig. 5, text-fig. 8g.
1963 *B. stimuliferum* (Deflandre); Sarjeant, pl. 70, fig. 17, text-fig. 8e.
1964 *B. stimuliferum* (Deflandre); Downie & Sarjeant: 97.
1964a *B. stimuliferum* (Deflandre); Sarjeant, table 3.
1965 *Solisphaeridium stimuliferum* (Deflandre); Staplin, Jansonius & Pocock: 183–184, pl. 18, figs. 1–2, text-figs. 3, 10.
1966 ?*B.* (*Micrhystridium*) *stimuliferum* (Deflandre); W. Wetzel, pl. 17, figs. 10a, 10b.
1968a *Solisphaeridium stimuliferum* (Deflandre); Sarjeant: 223, pl. 3, fig. 6, text-fig. 1.

Description. The shell is subspherical to ovate in shape, with a smooth surface and a thin wall. The processes are hollow, conical, straight or curved, and variable in length. The spine cavities are connected with the shell interior. An irregular break opens the shell.

FIGURED SPECIMENS. BM(NH) slide V.53949(3). From sample RB 219. Clay, immediately base of Kimmeridge Clay, *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset.

DIMENSIONS. English specimens (50 specimens measured) : shell length 20–30 $\mu$, breadth 18–28 $\mu$, process length 15–30 $\mu$. Scottish specimens (3 specimens measured): shell diameters 20–25 $\mu$, process length 10–15 $\mu$. French specimens (70 specimens measured) : shell length 21–33 $\mu$, breadth 20–30 $\mu$, process length 16–28 $\mu$.

REMARKS. This Upper Jurassic species was found to be abundant in the base of the Kimmeridgian of Dorset and France ; the specimens are generally well preserved.

*S. Stimuliferum* is closely similar to *M. fragile* ; it is, however, consistently larger than *M. fragile*. *S. stimuliferum* is also similar to *Veryhachium irregulare* and *V. rhomboidium* ; differences are that *S. stimuliferum* has diameters consistently above 20 $\mu$, whereas the species of *Veryhachium* may be smaller than 20 $\mu$ ; the number of processes is 12–22 in *S. stimuliferum*, but these two species of *Veryhachium* have 3–8 processes. The bases of the processes can clearly be recognized in *S. stimuliferum*, whereas they merge progressively into the shell wall and the point of junction is difficult to place precisely in the species of *Veryhachium*.

## SUBGROUP *NETROMORPHITAE* Downie, Evitt & Sarjeant, 1963

### Organism *A*

(Pl. 11, fig. 9)

DESCRIPTION. The shell is elongate, thin-walled, without ornamentation processes or division into fields. The shell surface is smooth. One pole is rounded, but the other is flattened with an opening on it.

FIGURED SPECIMEN. BM(NH) slide V.53948(2). Clay from immediately base of Kimmeridge Clay (*Rhactorhynchia inconstans* bed), Ringstead Bay, Dorset (RB 219).

DIMENSIONS. Figured specimens : length 77 $\mu$, breadth 28 $\mu$. The range of the English specimens (9 specimens measured) : length 58–78 $\mu$, breadth 25–48 $\mu$. Only one French specimen was measured : length 65 $\mu$, breadth 30 $\mu$.

REMARKS. This new form was observed in the assemblages from Dorset and Le Havre. Specimens are generally severely damaged or folded. This form is similar to the members of the subgroup Netromorphitae ; however, the details of its shape and position of the opening afford differences from all described species. Further study may necessitate the erection of a new taxon to accommodate these forms, but information about the range in morphology is, at present, insufficient to justify this.

Subgroup *POLYGONOMORPHITAE* Downie, Evitt & Sarjeant, 1963

Genus ***VERYHACHIUM*** Deunff, emend. Downie & Sarjeant, 1963

***Veryhachium hyalodermum*** (Cookson) Downie & Sarjeant, 1963

(Pl. 4, fig. 9 ; Pl. 12, fig. 11)

1956 *Palaeotetradinium hyalodermum* Cookson: 188–189, pl. 1, figs. 12–16.
1961 *P. hyalodermum* Cookson; Alberti, pl. 7, figs. 14, 15, ?18.
1963 *Veryhachium hyalodermum* (Cookson); Downie & Sarjeant: 94.
1963 *V. hyalodermum* (Cookson); Schaarschmidt: 62–63, pl. 17, figs. 1–7, text-fig. 12.
1964 *V. hyalodermum* (Cookson); Downie & Sarjeant: 151.
1964a *V. hyalodermum* (Cookson); Sarjeant, table 3.

Remarks. This species was originally recorded from Cretaceous (Albian-Cenomanian and ? Turonian) of Australia by Cookson (1956), and named as *Palaeotetradinium hyalodermum*. Alberti observed similar specimens from the Middle Jurassic of Germany and from the Cretaceous of Germany and Poland (1961). When Downie and Sarjeant emended the diagnosis of *Veryhachium*, the species was transferred to this genus by them (1963) on the basis of its general shape and of the structure of its processes. It is infrequently present in the basal Kimmeridgian assemblages.

Figured specimens. BM(NH) slide V.53961(1). Clay from Great Ouse River Board Pit, Stretham, Cambridgeshire (SC 444).

BM(NH) slide V.53620(3). Shale from 100 ft. above the second dolerite sill, Staffin Bay, Skye (SS 627).

Dimensions. Range of the English specimens (7 specimens measured) : overall cross-measurement 12 × 12 μ, process length 3–10 μ. The dimensions of the French specimen : overall cross-measurement 48 × 48 μ, process length 25 μ. Scottish specimen's cross-measurements 25 × 25 μ.

Subgroup *PRISMATOMORPHITAE* Downie, Evitt & Sarjeant, 1963

Genus ***STAPLINIUM*** Jansonius, 1962

Emended diagnosis. Unicellular microfossils, cubic to prismatic in shape with sharp edges, but without projections at the angles. The shell is thin-walled and encloses a central cavity. The surface of the test is smooth or granular. Some forms have a large opening on one side of the shell, which is typically the long side.

Type species. *Staplinium hexaeder* Jansonius, 1962, Lower Triassic western Canada.

***Staplinium cistum*** sp. nov.

(Pl. 12, fig. 5 ; Pl. 14, figs. 4, 7)

Derivation of the name. Latin, *cista* box, chest, with reference to the shape of the microfossil.

DIAGNOSIS. A *Staplinium* with polyhedral—roughly coffin-shaped test, thin-walled without any ornamentation or processes. The surface is smooth ; a large opening (pylome) is sometimes present on one side of the test.

HOLOTYPE. BM(NH) slide V.53950(2). Clay from the base of Kimmeridge Clay, *Rhactorhynchia inconstans* Bed, Ringstead Bay, Dorset (RB 219).

DIMENSIONS. Holotype : length 55 $\mu$, breadth 30 $\mu$. Range of English specimens (20 specimens measured) : length 23–73 $\mu$, breadth 18–64 $\mu$. Scottish specimens (2 specimens measured) : length 30–60 $\mu$, breadth 15–35 $\mu$.

DESCRIPTION. This form is a unicellular microfossil, cubic to prismatic in shape. It is thin-walled with a central cavity, without any processes. In some forms, a large opening, formed by the loss of one side of the test, was observed.

REMARKS. Hitherto only one species of *Staplinium* has been recorded : *Staplinium hexaeder* (Jansonius, 1962) from the Lower Triassic of Canada. The specimens of this new species were observed from the Dorset and Scottish assemblages only. These are similar to *S. hexaeder*, but whereas *S. hexaeder* has a granular surface, *S. cistum* has a smooth surface and is longer than *S. hexaeder* (as quoted by Jansonius : length 10–50 $\mu$). Openings have not been recorded in the latter species.

## SUBGROUP *PTEROMORPHITAE* Downie, Evitt & Sarjeant, 1963

## Genus ***PTEROSPERMOPSIS*** W. Wetzel, 1952

### ***Pterospermopsis australiensis*** Deflandre & Cookson, 1955

(Pl. 12, fig. 6)

1955 *Pterospermopsis australiensis* Deflandre & Cookson, 286–288, pl. 3, fig. 4, text-figs. 52–53.
1964 *P. australiensis* Deflandre & Cookson; Downie & Sarjeant: 143.

REMARKS. This species has previously been recorded from the Lower Cretaceous of Australia. Specimens were observed, in a moderate number, in the assemblages from Dorset, Stretham and the Boulonnais. Their preservation was, generally, not good. With this observation, the stratigraphic and geographic range of this species are extended from the Lower Cretaceous to the Upper Jurassic and from Australia to France and England.

FIGURED SPECIMEN. BM(NH) slide V.53941(1). Clay from 6 ft. below top of the Black Clay, Holworth, Dorset (HD 191).

DIMENSIONS. Figured specimen : overall diameters 23 × 23 $\mu$, shell diameters 14 × 14 $\mu$. Range of the English specimens (2 specimens measured) : overall diameters 23–50 $\mu$, shell diameters 14–40 $\mu$. Scottish specimens (5 specimens measured) : overall diameters 25–30 $\mu$, shell diameters 8–11 $\mu$. The French specimen could not be measured because of poor preservation.

### *Pterospermopsis helios* Sarjeant, 1959

(Pl. 4, fig. 8)

1959b *Pterospermopsis helios* Sarjeant: 342, pl. 13, fig. 9.
1964 *P. helios* Sarjeant; Downie & Sarjeant: 143.
1964a *P. helios* Sarjeant; Sarjeant, table 3.
1966 *P. helios* Sarjeant; Schulz & Mai, table 1.

Remarks. This species has previously been recorded from the Upper Jurassic (Upper Cornbrash) of England (Yorkshire) by Sarjeant, 1959. A single well-preserved specimen was observed from the Stretham material only.

Figured specimen. BM(NH) slide V.53963(1). Clay from Great Ouse River Board Pit, Stretham, Cambridgeshire (SC 444).

Dimensions. Overall diameters 20 $\mu$, shell diameters 11 $\mu$. Holotype dimensions (as quoted by Sarjeant) : overall diameters 25 $\mu$, shell diameters 10 $\mu$.

## V. CONCLUSIONS

In the assemblages described here, 82 species of Dinoflagellate cysts and 11 species of Acritarcha are present ; their distribution by horizon is shown in Tables 4 A and B. The Kimmeridge Clay assemblages are remarkably rich and varied. It is clear that a number of the species, which have a relatively limited stratigraphic range, will prove of considerable value as stratigraphic indices.

Proximate cysts are dominant at all horizons ; chorate and cavate cysts are present in variable quantity. There is a greater variety of chorate cysts present in the Dorset assemblages than in the French assemblages. 16 species of chorate dinoflagellate cysts were recorded, 5 of these not being observed in the French and 6 not being present in the Scottish assemblages. The chorate cysts are thus less varied in the French assemblages, but they are represented in greater number than in the Dorset assemblages, as seen below.

| | Dorset assemblages | Scottish assemblages | French assemblages |
|---|---|---|---|
| Number of species of chorate cysts | 16 | 10 | 11 |
| Total number of chorate cysts | 343 | 76 | 381 |

Generally the chorate cysts are dominant over the cavate cysts in number, in both the Dorset and the French assemblages :

| | Dorset assemblages | Scottish assemblages | French assemblages |
|---|---|---|---|
| Total number of chorate cysts | 343 | 76 | 381 |
| Total number of cavate cysts | 139 | 39 | 221 |

Acritarchs are represented by a few species ; *Solisphaeridium stimuliferum* (Deflandre) Staplin, Jansonius & Pocock and *Micrhystridium fragile* Deflandre are dominant :

| | Dorset assemblages | Scottish assemblages | French assemblages |
|---|---|---|---|
| Number of *M. fragile* | 91 | 2 | 17 |
| Number of *S. stimuliferum* | 92 | 3 | 152 |
| Total number of acritarchs | 360 | 23 | 228 |

## TABLE 4A

The numerical distribution of Proximate Dinoflagellate cysts in the base of Kimmeridgian assemblages from England, Scotland and France, compared with their previously known stratigraphic range.

| Species | No. of samples examined: England | | | | | | | | Scotland | | | France | | | | | | | | | Previously known range |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OM 131 | OM 418 | OM 419 | OM 420 | HD 191 | RB 218 | RB 219 | SC 444 | SS 625 | SS 626 | SS 627 | VN 184 | CH 185 | CH 186 | CC 447 | CC 448 | CC 449 | CC 450 | CC 451 | CC 452 | CC 455 | |
| DINOFLAGELLATE CYSTS PROXIMATE | | | | | | | | | | | | | | | | | | | | | | |
| *Chytroeisphaeridia chytroeides* | 21 | 17 | 14 | 16 | — | — | — | 18 | 18 | 11 | 8 | — | 42 | 29 | — | 4 | 2 | — | — | — | — | L.–M. Oxfordian |
| *C. pocockii* | 10 | 3 | 1 | 1 | — | — | — | 4 | 5 | 7 | 6 | — | 1 | 1 | — | — | 1 | — | — | 1 | — | L.–U. Callovian |
| *Tenua* cf. *capitata* | — | — | 1 | — | — | 1 | 6 | 1 | — | — | — | — | 1 | — | — | 1 | 1 | — | — | — | — | — |
| *T. hystrix* | 15 | 3 | 1 | 1 | — | 1 | 9 | 12 | 5 | 1 | 3 | 5 | 6 | 3 | — | 1 | 5 | 1 | — | 2 | 1 | Aptian |
| *T. pilosa* | 10 | 1 | 3 | — | — | — | 7 | 9 | 4 | 2 | 1 | — | 1 | — | — | — | — | — | — | — | — | U. Callovian–Oxfordian |
| *T.* sp. | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Acanthaulax venusta* | — | 1 | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | Malm Alpha-Beta |
| *Cryptarchaeodinium calcaratum* | — | — | — | — | — | — | — | 1 | — | — | — | — | 1 | — | — | — | — | — | — | — | — | L. Kimmeridgian |
| *C.* sp. | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — |
| *Gonyaulacysta aculeata* | — | — | — | — | — | — | — | 1 | — | — | — | 1 | 1 | — | 2 | — | — | — | — | — | — | Malm Gamma |
| *G. angulosa* | — | — | — | — | — | — | 1 | — | — | — | — | 1 | — | — | — | — | 1 | — | 1 | — | — | — |
| *G. cladophora* | — | — | — | — | — | — | — | 1 | 4 | 4 | 1 | — | — | — | 1 | — | — | — | — | — | — | Bajocian–Albian |
| *G. ehrenbergii* | — | — | — | — | — | — | — | — | — | — | — | 2 | — | — | 2 | 1 | — | — | — | — | — | — |
| *G. eisenacki* | 4 | — | — | — | — | — | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | M. Jurassic–U. Oxfordian |
| *G.* cf. *eisenacki* | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 3 | — | — | — | — |
| *G. granulata* | 1 | 1 | — | — | — | — | — | — | — | — | — | — | — | 1 | 2 | 4 | — | 8 | — | — | 1 | L. Oxfordian–U. Kimmeridgian |
| *G. granuligera* | — | 3 | 2 | 2 | 2 | 7 | — | — | — | — | — | 2 | — | — | 3 | 4 | 3 | 15 | 1 | 6 | 1 | L. Kimmeridgian |
| *G.* cf. *helicoidea* | — | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — |
| *G. hyaloderma* | — | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | M.-U. Kimmeridgian–Eocene |
| *G. jurassica* | 3 | 3 | 6 | 20 | 1 | 50 | 63 | 1 | 10 | 8 | 20 | 9 | 22 | 6 | 2 | 4 | — | 5 | 1 | — | — | Bathonian–Kimmeridgian |
| *G. jurassica* var. *longicornis* | — | — | 1 | — | — | — | — | — | 1 | — | — | — | 2 | — | — | — | — | 3 | — | — | — | Oxfordian |
| *G. longicornis* | — | — | — | — | — | — | — | — | — | — | — | — | 2 | — | 6 | — | 3 | 2 | — | — | — | Kimmeridgian |
| *G.* cf. *mamillifera* | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — |
| *G. nuciformis* | 2 | 3 | 2 | 1 | 1 | — | 7 | 4 | 1 | 6 | 1 | 1 | — | 1 | 1 | — | — | — | 9 | 1 | 7 | 1 | U. Jurassic |
| *G. pachyderma* | — | — | — | — | — | — | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | Oxfordian |
| *G. serrata* | 2 | — | 2 | 3 | — | — | 2 | — | 1 | — | — | 6 | — | — | — | 1 | — | 2 | — | — | — | Tithonian–Neocomian |
| *G.* sp. A | — | — | — | — | — | — | — | 1 | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — |
| *G.* sp. B | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — |
| *G.* sp. C | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 5 | — | — | — | — | — | — | — |
| *Occisucysta balios* | — | — | — | — | — | — | 1 | — | — | — | — | 2 | — | — | 1 | — | — | 1 | — | — | — | — |
| *O.* sp. | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Leptodinium amabilis* | — | — | 1 | — | — | — | — | 1 | — | — | — | — | 1 | — | — | — | — | — | — | — | — | L. Kimmeridgian |
| *L. arcuatum* | 2 | — | — | 1 | — | — | 2 | — | — | — | — | 1 | — | — | — | 1 | — | — | — | 1 | — | U. Oxfordian |
| *L. clathratum* | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | Oxfordian–Tithonian |
| *L. egemenii* | 9 | 6 | 1 | — | 2 | 1 | 1 | — | — | — | 1 | — | 11 | 3 | — | — | — | — | — | — | — | — |
| *L.* cf. *subtile* | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Belodinium dysculum* | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | Tithonian |
| *Dictyopyxis areolata* | — | — | — | — | — | — | — | — | 1 | — | 1 | — | 1 | — | — | — | 1 | — | — | — | — | M. Callovian–Kimmeridgian |
| *D.* sp. | 2 | — | — | 2 | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — |
| *Histiophora* cf. *ornata* | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | 1 | — | 1 | — | — | — | — | — |
| *Meiourogonyaulax staffinensis* | 3 | — | — | — | 1 | — | 5 | — | 3 | — | 2 | 1 | — | — | 1 | — | — | 3 | — | — | 1 | — |
| *M.* sp. | — | — | — | — | — | — | — | — | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Apteodinium granulatum* | — | — | — | — | — | — | 5 | 1 | — | — | — | 1 | — | — | — | — | — | 5 | 1 | — | — | Volgian–Cenomanian |
| *A.* cf. *maculatum* | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | 1 | — | — | — | — |
| *Pareodinia ceratophora* | 8 | 5 | 4 | 5 | — | 5 | 14 | 10 | 3 | 1 | 1 | 3 | 14 | 1 | 2 | 12 | 2 | 5 | — | 1 | — | Bajocian–U. Oxfordian |
| *Trichodinium* sp. | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Imbatodinium* sp. | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — |
| *Nannoceratopsis pellucida* | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | U. Oxfordian -L. Kimmeridgian |
| Indetermined Proximate cysts | 46 | 25 | 32 | 24 | 4 | 32 | 149 | 58 | 30 | 19 | 25 | 60 | 54 | 26 | 66 | 64 | 57 | 113 | 10 | 90 | 6 | — |

## Table 4B

The numerical distribution of Chorate, Proximochorate and Cavate Dinoflagellate cysts and Acritarchs in the basal Kimmeridgian assemblages from England, Scotland and France, compared with their previously known stratigraphic range.

| Species | No. of samples examined | | | | | | | | | | | | | | | | | | | Previously known range |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | England | | | | | | | | Scotland | | | France | | | | | | | | |
| | OM | OM | OM | OM | HD | RB | RB | SC | SS | SS | SS | VN | CH | CH | CC | CC | CC | CC | CC | CC |

TABLE 4B

The numerical distribution of Chorate, Proximochorate and Cavate Dinoflagellate cysts and Acritarchs in the basal Kimmeridgian assemblages from England, Scotland and France, compared with their previously known stratigraphic range.

| Species | No. of samples examined: England | | | | | | | | Scotland | | | France | | | | | | | | | Previously known range |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OM 131 | OM 418 | OM 419 | OM 420 | HD 191 | RB 218 | RB 219 | SC 444 | SS 625 | SS 626 | SS 627 | VN 184 | CH 185 | CH 186 | CC 447 | CC 448 | CC 449 | CC 450 | CC 451 | CC 452 | CC 455 | |
| CHORATE | | | | | | | | | | | | | | | | | | | | | | |
| *Cleistosphaeridium ehrenbergi* | 6 | 1 | — | — | — | 5 | 2 | — | — | — | 1 | — | 2 | — | 2 | — | — | — | — | — | — | L. Oxfordian |
| *C. polyacanthum* | 1 | 1 | — | — | — | 5 | 4 | — | — | — | — | — | 5 | 2 | 3 | — | — | — | — | — | — | — |
| *C. polytrichum* | 2 | — | 1 | 1 | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | Bathonian–Kimmeridgian |
| *C. tribuliferum* | 4 | 1 | 3 | — | — | 11 | 8 | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | Callovian–Oxfordian |
| *C.* sp. | — | — | — | 1 | — | — | — | — | 1 | — | — | 1 | 1 | — | 1 | 1 | — | — | — | — | — | — |
| *Hystrichosphaeridium pelilum* | 2 | — | 2 | — | — | 26 | 2 | — | 2 | 6 | 3 | 6 | — | — | — | — | — | — | — | — | — | — |
| *Oligosphaeridium pulcherrimum* | — | — | — | — | — | — | 2 | — | — | — | — | — | — | — | — | — | 3 | — | — | — | — | Cretaceous |
| *Polystephanephorus sarjeantii* | 7 | 1 | — | — | — | 2 | — | — | — | — | — | — | — | 1 | — | — | 2 | — | 2 | — | — | — |
| *Prolixosphaeridium* cf. *deirense* | — | — | — | — | — | — | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *P. granulosum* | 7 | 1 | 3 | — | 1 | 19 | 1 | 3 | 2 | 6 | 4 | 1 | 4 | — | 1 | — | — | — | — | — | — | Oxfordian–Eocene |
| *P. parvispinum* | — | — | — | 2 | — | — | 1 | — | 2 | — | — | — | — | — | — | — | — | — | — | — | — | Oxfordian–Eocene |
| *Systematophora areolata* | 1 | 6 | 7 | 5 | — | 2 | 4 | 4 | 5 | 2 | 9 | 51 | 6 | 6 | 76 | 5 | 6 | 14 | 11 | 15 | — | Malm Delta |
| *S. orbifera* | 1 | 13 | 3 | 2 | — | 21 | — | — | 4 | 1 | 1 | 3 | — | — | 32 | 3 | 5 | 4 | 3 | 13 | — | U. Oxfordian–L. Kimmeridgian |
| *S.* sp. | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Taeniophora tunctispina* | 2 | — | 2 | — | — | 2 | 3 | — | 3 | — | — | 3 | 2 | 1 | 4 | — | 1 | — | 3 | 1 | — | Malm Alpha |
| *Stephanelytron* cf. *scarburghense* | 5 | 2 | — | — | — | — | 3 | — | — | — | 3 | — | 1 | — | — | — | — | — | — | — | 1 | — |
| Indeterminate Chorate cysts | 16 | 7 | 5 | 4 | 1 | 32 | 32 | 6 | 8 | 2 | 12 | 24 | 8 | 4 | 12 | 6 | 11 | 11 | 10 | 11 | — | — |
| PROXIMOCHORATE | | | | | | | | | | | | | | | | | | | | | | |
| *Hesliertonia pellucida* | — | — | — | — | — | — | — | 1 | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — |
| *Epiplosphaera reticulospinosa* | 2 | 1 | 1 | 1 | — | — | — | 2 | — | — | — | 2 | — | — | — | — | — | — | — | — | — | Malm Delta |
| Indeterminate proximochorate cysts | — | — | — | 3 | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — |
| CAVATE | | | | | | | | | | | | | | | | | | | | | | |
| *Endoscrinium* cf. *campanula* | 3 | 2 | — | 1 | — | — | — | — | — | 1 | — | — | — | — | 7 | 4 | 1 | 3 | — | — | — | — |
| *E. galeritum* | 3 | — | — | — | — | — | 1 | — | — | — | — | — | — | — | 2 | — | — | — | — | — | — | Callovian–Kimmeridgian |
| *E. luridum* | 2 | — | 1 | — | — | — | — | — | 5 | 2 | 1 | 2 | — | — | — | — | — | — | — | — | 1 | Callovian–Kimmeridgian |
| *E. oxfordianum* | 1 | — | — | — | — | — | — | — | 3 | — | 1 | 3 | 1 | — | — | — | — | — | — | — | — | Oxfordian |
| *Psaligonyaulax apuleta* | 1 | — | 5 | 5 | — | — | — | 2 | — | — | — | 2 | 2 | 1 | 3 | 1 | — | 3 | — | — | — | U. Oxfordian–L. Kimmeridgian |
| *P.* sp. | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| *Hexagonifera* sp. | 1 | — | — | 1 | — | — | — | — | — | — | 1 | — | 2 | — | — | — | 1 | — | — | — | — | — |
| *Parvocavatus tuberosus* | — | 1 | — | 2 | — | — | — | 3 | 1 | — | — | 21 | — | 24 | 1 | 22 | 1 | 5 | 1 | — | — | — |
| *Scriniodinium bicuneiformi* | — | 1 | 2 | — | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | U. Oxfordian–L. Kimmeridgian |
| *S. crystallinum* | 3 | 3 | — | 3 | — | 8 | — | — | 1 | 2 | 2 | 1 | 2 | — | — | 1 | — | — | 1 | — | 3 | Oxfordian–Kimmeridgian |
| *S. dictyolum* subsp. *osmingtonensis* | 3 | — | 3 | 3 | — | — | — | — | — | — | — | — | — | — | — | 2 | — | — | — | — | — | — |
| *S. dictyolum* subsp. *papillatum* | — | — | — | 2 | — | — | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — |
| *S. dictyolum* subsp. *pyrum* | — | 1 | 2 | — | — | — | 1 | — | — | — | — | — | 1 | 1 | — | — | — | — | — | — | — | — |
| *S.* cf. *galeatum* | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | 2 | — | — | — | — | — | — |
| *S. playfordi* | — | — | 1 | — | — | — | — | — | — | — | — | — | 1 | — | 4 | — | — | — | — | — | — | U. Oxfordian–L. Kimmeridgian |
| *Netrelytron parum* | 14 | 6 | 4 | 8 | 1 | — | — | 1 | — | — | — | 6 | 2 | 2 | — | 1 | 1 | 12 | 4 | 1 | — | — |
| *N. stegastum* | 12 | — | — | — | — | — | — | — | — | — | — | 1 | 3 | — | — | — | — | — | — | — | — | Oxfordian |
| *Odontochitina* sp. | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Indeterminate cavate cysts | 6 | 1 | 5 | 4 | 1 | 2 | 7 | 6 | 7 | 4 | 8 | 10 | 4 | 8 | 7 | 15 | 2 | 9 | — | — | 8 | — |
| Dinoflagellate sp. indet. | 35 | 14 | 23 | 8 | 30 | 17 | 106 | 15 | 8 | 7 | 16 | 26 | 38 | 13 | 22 | 32 | 21 | 50 | 29 | 25 | 18 | — |
| ACRITARCHA | | | | | | | | | | | | | | | | | | | | | | |
| *Baltisphaeridium inusitatum* | — | — | — | 1 | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | Malm Gamma |
| *Micrhystridium fragile* | 1 | 7 | 2 | 6 | 1 | 11 | 9 | 25 | — | 1 | 5 | 8 | 5 | 2 | 4 | 5 | 1 | 4 | — | — | — | Bajocian–Oxfordian |
| *M. inconspicuum* | — | 4 | 1 | 4 | 1 | 1 | — | 80 | 2 | — | — | 2 | 12 | 2 | 1 | — | — | — | — | — | — | Bajocian–Cretaceous |
| *M. sydus* | — | — | — | 1 | — | 1 | — | 18 | — | 3 | — | — | 4 | — | — | — | — | — | — | — | — | Bathonian–Oxfordian |
| *Solisphaeridium brevispinosum* | 3 | — | — | 1 | — | — | — | — | — | — | — | — | 3 | — | — | — | — | — | — | — | — | U. Callovian–Oxfordian |
| *S. stimuliferum* | 11 | 6 | 4 | 9 | — | 36 | 22 | 7 | 1 | 1 | 1 | 24 | 15 | 1 | 33 | 17 | 4 | 4 | 54 | — | — | Bajocian–Oxfordian |
| Organism A | — | 1 | — | 1 | — | — | 11 | — | — | — | — | — | 2 | — | — | — | — | — | — | — | — | — |
| *Veryhachium hyalodermum* | — | — | — | — | — | — | — | 10 | — | — | 1 | 1 | — | — | — | — | — | — | — | — | — | Albian–?Turonian |
| *Pterospermopsis australiensis* | — | — | — | — | 1 | — | — | 1 | 6 | — | — | — | — | — | — | — | — | — | — | — | — | Lower Cretaceous |
| *P. helios* | — | — | — | — | — | — | — | 1 | — | — | — | — | — | — | — | — | — | — | — | — | — | Upper Jurassic |
| *Staplinium cistum* | 5 | — | — | — | — | — | 17 | — | 1 | — | 1 | — | — | — | — | — | — | — | — | — | — | — |
| Indeterminate acritarchs | 3 | 1 | 1 | 3 | 3 | 6 | 17 | 5 | — | — | — | 3 | 13 | — | 3 | — | — | — | — | — | — | — |
| Pollen and Spores | 39 | 13 | 27 | 6 | 18 | 41 | 213 | 45 | 40 | 76 | 56 | 10 | 28 | 20 | 8 | 18 | 4 | 32 | 12 | 22 | 73 | — |
| Foraminiferal shell linings | — | — | 5 | 1 | — | — | — | 9 | 13 | 3 | 4 | — | — | — | — | 1 | 3 | — | — | — | — | — |
| Wood fragments | 3 | — | — | — | — | — | 5 | — | 4 | 4 | 1 | — | — | — | — | 3 | — | — | — | — | — | — |
| Total | 342 | 167 | 185 | 166 | 70 | 345 | 756 | 371 | 206 | 176 | 202 | 311 | 328 | 163 | 322 | 235 | 141 | 329 | 145 | 196 | 115 | |

On the basis of previous published records, the following species here described were known only from the Lower Kimmeridgian : *Cryptarchaeodinium calcaratum* Deflandre, *Gonyaulacysta granuligera* (Klement) Sarjeant, *Leptodinium amabilis* (Deflandre) Sarjeant, *Systematophora areolata* Klement, *Epiplosphaera reticulospinosa* Klement and *Baltisphaeridium inusitatum* Klement. *Gonyaulacysta hyaloderma* (Deflandre) Sarjeant and *G. longicornis* (Downie) Sarjeant have both been previously reported from Kimmeridgian, *G. hyaloderma* having been observed in the Middle Kimmeridgian and *G. longicornis* having a stratigraphic range including Upper Kimmeridgian ; both these species are represented in the basal Kimmeridgian.

Seven species previously known from U. Oxfordian and L. Kimmeridgian are also present in the basal Kimmeridgian assemblages of England, Scotland and France. These are : *Acanthaulax venusta* (Klement) Sarjeant, *Nannoceratopsis pellucida* Deflandre, *Systematophora orbifera* Klement, *Taeniophora iunctispina* Klement, *Psaligonyaulax apaleta* (Cookson & Eisenack) Sarjeant, *Scriniodinium bicuneatum* (Deflandre) Sarjeant and *S. playfordi* Cookson & Eisenack.

Fourteen species were previously known only from lower horizons and were observed in the basal Kimmeridgian assemblages for the first time : *Chytroesphaeridia chytroeides* Sarjeant (L.–M. Oxfordian), *C. pococki* Sarjeant (L.–U. Callovian), *Tenua pilosa* (Ehrenberg) Sarjeant (U. Callovian–Oxfordian), *Gonyaulacysta eisenacki* (Deflandre) Sarjeant (M. Callovian–U. Oxfordian), *G. nuciformis* (Deflandre) Sarjeant (U. Callovian–Oxfordian), *G. pachyderma* (Deflandre) Sarjeant (Oxfordian), *Leptodinium arcuatum* Klement (U. Oxfordian), *Pareodinia ceratophora* Deflandre (M. Callovian–U. Oxfordian), *Cleistophaeridium ehrenbergi* Deflandre (L. Oxfordian), *C. tribuliferum* Sarjeant (Oxfordian), *Endoscrinium oxfordianum* Sarjeant (Oxfordian), *Netrelytron stegastum* Sarjeant (Oxfordian), *Solisphaeridium brevispinosum* Sarjeant (Oxfordian) and *S. stimuliferum* (Deflandre) Staplin, Jansonius & Pocock (Bajocian–Oxfordian). Assemblages of the basal Kimmeridgian are very close to the Callovian and Oxfordian assemblages.

Seven species previously recorded from higher horizons were observed for the first time in the basal Kimmeridgian : *Tenua hystrix* Eisenack (Aptian), *Gonyaulacysta serrata* (Cookson & Eisenack) Sarjeant (Tithonian–Neocomian), *Belodinium dysculum* Cookson & Eisenack (Tithonian), *Apteodinium granulatum* Eisenack Volgian–Cenomanian), *Oligosphaeridium pulcherrimum* (Deflandre & Cookson) Davey & Williams (Cretaceous) and *Pterospermopsis australiensis* Deflandre & Cookson (L. Cretaceous).

The other 21 previously observed species are long-ranging forms whose known range includes the Kimmeridgian : 14 of them were also known from the Oxfordian. These observations indicate that these species have more affinities with Oxfordian deposits. No detailed work on Portlandian assemblages is available, but it may be noted that some basal Kimmeridgian species suggest relationships with the Lower Cretaceous (Barremian–Cenomanian) assemblages.

Representatives of 7 species were observed in the basal Kimmeridgian assemblages for the first time in Western Europe, having been previously recorded only from Australian and New Guinea assemblages. These are *Gonyaulacysta serrata* Cookson & Eisenack, *Leptodinium clathratum* (Cookson & Eisenack) Sarjeant, *Belodinium dyscu-*

*lum* Cookson and Eisenack, *Oligosphaeridium pulcherrimum* Deflandre & Cookson, *Psaligonyaulax apaleta* (Cookson & Eisenack) Sarjeant, *Scrinidinium playfordi* Cookson & Eisenack and *Pterospermopsis australiensis* Cookson & Eisenack. 4 of these 7 species were observed in both English and French assemblages : *Gonyaulacysta serrata, Psaligonyaulax apaleta, Scriniodinium playfordi* and *Pterospermopsis australiensis* ; one, *Belodinium dysculum*, only in the Dorset assemblage, and the remaining 3 were observed only from the French assemblages.

Eleven species previously recorded from Germany were observed in the English and French assemblages for the first time : *Tenua hystrix* Eisenack, *Acanthaulax venusta* (Klement) Sarjeant, *Gonyaulacysta aculeata* (Klement) Sarjeant, *G. eisenacki* (Deflandre) Sarjeant, *G. granulata* (Klement) Sarjeant, *G. granuligera* (Klement) Sarjeant, *Leptodinium arcuatum* Klement, *Systematophora areolata* Klement, *S. orbifera* Klement, *Taeniophora iunctispina* Klement, and *Epiplosphaera reticulospinosa* Klement.

The previous studies and this study indicate that 8 species are present in assemblages both from England and France : *Pareodinia ceratophora* Deflandre, *Cleistosphaerdium ehrenbergi* Deflandre, *C. polytrichum* (Valensi) Davey, Downie, Sarjeant & Williams, *Prolixosphaeridium granulosum* (Deflandre) Sarjeant, *Scriniodinium bicuneatum* (Deflandre) Sarjeant, *Micrhystridium inconspicuum* Deflandre, *Solisphaeridium brevispinosum* (Sarjeant) Sarjeant, and *S. stimuliferum* (Deflandre) Sarjeant. 4 of these species were formerly represented only in French assemblages : *Chytroeisphaeridia pococki* Sarjeant, *Cryptarchaeodinium calcaratum* Deflandre, *Gonyaulacysta pachyderma* (Deflandre) Sarjeant, and *Leptodinium amabilis* (Deflandre) Sarjeant. 4 species hitherto known only from England are also present in the basal Kimmeridgian assemblages of France : *Chytroeisphaeridia chytroeides* Sarjeant, *Gonyaulacysta longicornis* (Downie) Sarjeant, *E. oxfordianum* Sarjeant, and *Netrelytron stegastum* Sarjeant.

A comparison of the Australian and Western European assemblages, as described by Cookson & Eisenack (1958, 1960 a, b, 1962 a, b), shows some differences between the size ranges of the Australian specimens and those of European : Australian specimens are, generally, considerably larger. When the European assemblages are compared, the English specimens are found to be slightly larger than the French and German specimens. This is, probably, the result of a palaeoecological control, i.e. food supply, climate, salinity, etc. No differences are observed within the species of Britain, that is, between the Scottish, Dorset and Stretham species. This might not be considered to be established by present evidence, however, for relatively small numbers of horizons have been examined in Scotland and from Stretham, Cambridgeshire.

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